# ROLE OF PRODUCTION AND MARKET INNOVATIONS ON COMPETITIVENESS OF SORGHUM AGRI-ENTERPRISES IN THARAKA NITHI COUNTY, KENYA

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## DECLARATION AND RECOMMENDATION

### Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

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### Recommendation

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

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## DEDICATION

I dedicate this work to my loving parents Mr Wilson Sirma and Mrs Rebecca Sirma and my siblings for their unconditional love and support. God bless you

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## ABSTRACT

Agricultural innovations, especially for sorghum, is key to economic growth, income stability as well as nutritional enhancement particularly in marginal areas since they are well-adapted to poor or unpredictable agro-ecological conditions. They are adaptable to arid and Semi-Arid arid lands (ASALs). The focus of this study was on the role of production and market innovation on the competitiveness of sorghum agrienterprises in Tharaka Nithi County, Kenya. The specific objectives in this study were; to examine production and market innovations used by small scale farm agrienterprises the effect of innovative capabilities, socioeconomics and institution characteristics on the level of use of these innovations and their role on the level of competitiveness of sorghum agrienterprises. The primary data used were collected from 384 randomly selected small scale agrienterprises from Tharaka Nithi County, using semi-structured questionnaires. Data was first cleaned and analysed using STATA 14. For data analysis, descriptive statistics, the Poisson model and multivalued treatment effects were used, respectively. The results show a majority of the sorghum agrienterprises in Tharaka County (80%) use production and market innovation such as improved sorghum seed varieties (78%), conservation agriculture (61%), group marketing (14%) and Capacity building (21%). The finding also, revealed that years of schooling, household size, farming experiences, market distance, access to information, group participation, contract arrangement and innovative capabilities significantly influence the use of innovation. The result further indicated that the gross margin and farm productivity of sorghum improved with an increase in the number of innovations used. The study concluded that the kind and the number of innovations employed in agrienterprises development is critical in its profitability and productivity. Therefore, interventions targeting usage of innovations on sorghum agrienterprises should consider years of schooling, household size and experience of the agriprenuers when introducing innovation to them and also deliberate on agrienterprises accessing information group participation, distance contract agreement and the number of the innovations for the competitiveness of agrienterprises. Moreover, enterprises ought to be encouraged to team up and actively participate in farmer groups to enable them to access farm innovation information and extension services.

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| | |
|---|---|
| **AIPW** | Augmented Inverse Probability Weight |
| **ASAL** | Arid and Semi-Arid Land |
| **ASDS** | Agricultural Sector Development Strategy |
| **DRE** | Double robust estimators |
| **EABL** | East Africa Breweries Limited |
| **EAML** | East Africa Malting Limited |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FGDs** | Focused Group Discussions |
| **GCI** | Global Competitiveness Index |
| **GDP** | Gross Domestic Product |
| **GOK** | Government of Kenya |
| **GPS** | General propensity score |
| **ICRISAT** | International Crop Research Institute for the Semi-Arid Tropics |
| **IPW** | Inverse Probability Weight |
| **IPWRA** | Inverse probability weight regression Adjusted |
| **KALRO** | Kenya Agriculture and Livestock Research Organization |
| **KCEP** | Kenya Cereal Enhancement Program |
| **KEPHIS** | Kenya Plant Health Inspectorate Services |
| **KIRDI** | Kenya Industrial Research Development Institute |
| **MLND** | Maize Lethal Necrosis Disease |
| **MoALF** | Ministry of Agriculture, Livestock and Fisheries |
| **RA** | Regression Adjustment |
| **SDGs** | Statistics and data |
| **STATA** | Sustainable Development Goals |
| **VIF** | Variance Inflation Factor |

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background to the study

Agricultural development is fundamental for sustainable economic development and reducing poverty levels in developing countries. It is also the primary source of food and a contributor to household economies. Agrienterprises hold a major share in the provision of raw materials for industries and the national economy (Dar & Laxmipathi, 2013). Similarly, Grebmer *et al.* (2010) maintain that income from agriculture is the major source of satisfaction in a nation's health and educational needs. Kenya's agriculture sector is important too in alleviating poverty, it contributes 60% of the employees earn their livelihood from the sector and also contribute to 50% of the country's gross domestic product (GDP), about 65% of the export earnings and 18% of the formal employment (GoK, 2017). In Kenya, 53% of the population lives below the poverty line, 93% of this population lives in arid and semi-arid lands, (Bolanle *et al.*, 2017).

According to Anita *et al.* (2019), Arid and Sem-Arid Lands (ASALs)experience erratic rainfall, rough terrains and nutrient-poor soils. ASALs in Kenya covers more than 80% of the country and are occupied by about 10 million Kenyans. The increase in population has led to the encroachment of these areas (Kogo *et al.,* 2021). Nearly 70% of the livestock reared is found in these areas with vulnerabilities to food insecurity, climate variability and change is high (Orr *et al.*, 2016). Besides, land degradation in the form of soil erosion and nutrient depletion poses a threat to the sustainability of agricultural production particularly in the ASALs (Ogada *et al.*, 2010). One of the common staple crops in the rural ASALs of Kenya is sorghum. It's the primary source of energy, protein, vitamins and micronutrients (Orr *et al.*, 2013), they are also considered climate-smart crops with extensive resilience and adaptation (Bolanle *et al.*, 2017). Therefore, sorghum can add to better food dietary and nutritional safety in this area than commonly produced cereals such as wheat, rice and maize since it is productivity is better in the ASALs region with low soil fertility (Onyango, 2016).

Innovations are considered a critical player in the agriculture sector in the development of the country's economic growth (Esparcia, 2013). They are seen to bring about productivity, competitiveness, quality and efficiency to farm agrienterprises (Mutsvangwa-Sammie *et al.*, 2017). Distanont and Khongmalai (2018) also added that innovation is important since it fosters

the creation of competitive advantage and increase capacity for small scale agriprenuers. The use of innovations enables agrienterprises to improve or develop a new product for their customers thus increasing its market size. Aziz and Samad (2016) stated that promotion of innovation is a tool that empowers agrienterprises to create sustainable enterprises by gathering knowledge, experiences in creating as well as developing agrienterprises, using skills in technology and generating new ideas under production, value addition, market innovation or business canvas. Moreover, Production and market innovations are essential to increasing the quantity and quality of agricultural produce for household income stability and food security in developing countries (Godfray *et al.,* 2010).

The use of technology market innovation is a resource-based advantage for agrienterprises to exchange knowledge and information on the opportunities available in the marketplace (Gupta *et al.,* 2016). The exchange of field notes among agrienterprises, sellers and buyers aid the search of unforeseen events and proof of identity of innovative ideas to increase the chance of market opportunities. The most probable way of agrienterprises improving their market creativities is by creating new marketing channels, reformulating the existing ones, ascertaining new managerial approaches and developing new services (Nenonen *et al.,* 2019). Such as collective marketing and contracting farming by agrienterprises. Lin *et al.* (2010), relates this market innovation to retailing channels, marketing information systems, market segmentation, market research and price-setting strategy.

However, Kenya's development partners have been involved in continuous cooperative development interventions to promote technologies and innovations for the competitiveness of sorghum agrienterprises in ASALs (Kavoi *et al.,* 2013). Recently, the government of Kenya in collaboration with international and national research organizations like the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in alliance with the Kenya Agricultural Livestock Research Organizations (KALRO) and Egerton University have developed interventions (Orr *et al.,* 2020). Through the collaboration, development, promotion of innovation and market linkage of the sorghum value chain has been facilitated innovation among other traditional crops like Finger millet, green grams, pigeon peas and cowpeas for marginal areas of Kenya to enhance the competitiveness of these agrienterprises. Such market-driven innovations and resource-conserving technologies such as; improved sorghum seed varieties, integrated weed, pest and disease control conservation practices, and the establishment of

aggregation facilities and training to reduce post-harvest losses have been documented (Jerop *et al.,* 2018).

The sorghum crop has high home consumption demand more so in urban areas. The price is also double that of maize, hence presences an opportunity for competitiveness for the sorghum (Oduori & Kanyenji, 2005). Besides, the promotion and adoption of these traditional crops in ASAL acts as a measure to alleviate the effects of climate change (Schipmann-Schwarze *et al.,* 2012). East African Maltings Ltd (EAML), a subsidiary of beer-maker East African Breweries Ltd (EABL), partnered with the Kenya Cereals Enhancement Program (KCEP) to improve sorghum agrienterprises in the Eastern region of Kenya. The initiative has reached more than 12,000 small scale farm agrienterprises for the supply of the cereals essential in the production of low-cost brews. On the other hand, EABL has initiatives that seek to raise its sorghum uptake three-fold to 30,000 tons a year. This boosts the demand for sorghum products in Kenya and the lower Eastern part of Kenya in general. Research conducted by KALRO shows that demand for 'Gadam' sorghum variety with good malting characteristics significantly increases as a result of the initiative from EABL (KALRO, 2014). EABL is also currently receiving sorghum supplies through contract farming which has stimulated innovative ways of processing, aggregation and market linkages (Reddy *et al.,* 2010).

Moreover, sorghum has great potential as a food and cash crop. These crops are highly nutritious, drought-tolerant, high yielding, disease-tolerant, and can yield produce with little input use (Orr *et al.,* 2016). Sorghum, for example, is proven by research to be a portion of healthy food, documentaries such as Njagi *et al*. (2017) show that it helps manage diabetes, cholesterol in the body and prevents the growth of cancer cells. Sorghum small grain has an extended shelf of several years without significant damage by storage pests, thus offering food security opportunities for the rural communities who are small scale farmers (Bolanle *et al.,* 2017). It also has high nutritional benefits owing to its high nutritive content especially for pregnant women, nursing mothers and children, provides carbohydrates with a low glycaemic index with high soluble fibre, high calcium, diastolic power and low fat of malted grains (Shasha *et al.,* 2016).

Carayannis and Grigoroudis (2016) stated that there is an inherent connection to the notion of innovation, productivity and competitiveness. Hence, collective efforts must be enhanced to promote innovations in the production and consumption of sorghum products, since

the agrienterprises provide adequate rewards to small scale agriprenuers, and also the consumers with high-quality food and feed (Gupta *et al.*, 2017). The agriculture sector plays a fundamental role in the Kenyan economy. This licenses policies to be designed on improving household food security and promotion of a specific type of crop to be grown by small scale farm agrienterprises, particularly in the marginal areas.

## 1.2 Statement of the problem

In Kenya, sorghum technologies that improve value chain efficiency, raise productivity and increase income in the Eastern region have been developed and deployed. These market-oriented innovations on production and outlet linkages of sorghum were designed to improve upstream and downstream points, upscaling and development of small-scale farm agrienterprises in product markets, but farm's competitiveness is low in ASALs. Sorghum is still produced under a subsistence production system. Although there is evidence of combined efforts in the application of these innovations, little information is available on the role of farmer innovative capability, socioeconomic and institutional characteristics in the uptake of the innovations. Further, there is limited empirical evidence on whether the uptake of the innovations has on sorghum competitiveness in small scale farm level agriprenuers in most ASALs of Eastern Kenya. Hence this study sought to bridge this knowledge gap by examining the role of production and marker innovation on the competitiveness of sorghum agrienterprises in Tharaka Nithi County, Kenya.

## 1.3 Objectives

### 1.3.1 General objective

The general objective of the study was to contribute towards improved farm performances and household livelihood through enhanced competitiveness of small-scale sorghum agrienterprises in Tharaka Nithi County, Kenya.

### 1.3.2 Specific objectives

i. To examine production and market innovations used by sorghum small scale farm agrienterprises in Tharaka Nithi County, Kenya.

ii. To examine the effects of farmers' innovative capability, socioeconomics and institutional characteristics on the level of use of production and market innovations among sorghum small scale agrienterprises in Tharaka Nithi County, Kenya.

iii. To determine the effects of production and market innovations on the level of competitiveness of sorghum small scale agrienterprises in Tharaka Nithi County, Kenya.

## 1.4 Research Questions

i. Which is the production and market innovations being used by small scale farm agrienterprises in Tharaka Nithi County, Kenya?

ii. What are the effects of farmers' innovative capability, socioeconomics and institutional characteristics on the level of use of production and market innovation among small scale agrienterprises in Tharaka Nithi County, Kenya?

iii. What are the effects of production and market innovations on the level of competitiveness of sorghum small scale agrienterprises in Tharaka Nithi Kenya?

## 1.5 Justification for the study

Underutilized cereal such as sorghum is one of the crops that has been argued to be a major contributor to the food basket and nutritional security in ASALs areas, as well as to income generation to resource-poor farmers in these low productivity areas. Therefore, these crops carry the potential to mitigate some of the most pressing issues in terms of food production and income generation in ASALs, as different innovations have been carried out for a long time by the government, NGOs and other development partners to enhance productivity and consumption in ASALs regions.

The finding of this study will be of great assistance to the government of Kenya as it will give guidance to develop suitable policies and engage agrienterprises development agencies to help sorghum small scale farm agrienterprises, improve their technological capabilities and become innovative to improve the quality and quantity of their products. Hence, elevate these agrienterprises to a competitive level and in the long run assist in achieving Kenya's vision 2030, while as, achieve the first and second goals of Kenya's sustainable development goal (SDGs), that is end poverty in all its forms everywhere and end hunger, achieve food security, improve nutrition and promote sustainable agriculture in the country.

## 1.6 Scope and limitation of the study

The study focused on small scale sorghum agrienterprises in ASALs. It was limited to production and market innovations. Other forms of innovations like organization innovation and value addition were beyond the scope of the study. The study targeted 384 respondents who were representative samples for small scale sorghum in Tharaka Nithi County hence, the results may not be representative of all sorghum farmers in Kenya. The data were collected using a semi-structured questionnaire, and since a majority of the farmers may not keep the cost of production and the agrienterprises records, thus the study depended on recall information. The failure of sorghum agriprenuers to give accurate information about the agrienterprises limited the study.

## 1.7 Definition of terms

**Competitiveness:** refers to the ability of small scale agrienterprises to get better returns from their marketable produce. For this study, indicators include production cost and profitability.

**Innovation:** refers to an idea, practice or project that is perceived as new by an agrienterprises

**Innovative capabilities:** an ability to develop new product and /or market, through aligning strategic innovative orientation with innovation behaviours and processes.

**Market innovation:** it involves the use of new marketing strategies, marketing concepts or new marketing methods to explore the new and existing market.

**Orphan Crops:** refer to species of a crop whose potential has not been fully utilized, such as sorghum

**Production Innovation**: is the development of a new production, making changes in the current production variety or using new techniques and means to improve production in the farm agrienterprises.

**Small scale agrienterprises:** refers to farmers with limited resource endowment whose production system is primarily for subsistence purposes.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.1 Overview of underutilized crops

Sorghum is native to the tropical areas of Africa. It is a crop that can be cultivated throughout the tropical, semi-tropical and arid regions of the world (Tadele, 2019). The underutilized crop is also known as "neglected and orphan species" is usually used to refer to species of a crop whose potential has not been fully utilized, these include sorghum (Padulosi *et al.,* 2002). In the past, these crops were wide cultivated but abandoned in favour of other modern crops today. Research is less as compared to commonly utilized and marketed cereals such as maize and wheat (Jerop *et al.,* 2018). They are small grains nevertheless they are a very significant source of food and generate income for small scale farmers (Hamukwala *et al.*, 2010). They are known for their unique ability to produce in ASALs characterised by harsh climatic conditions, areas with limited rainfall, and with low fertility in the soils and fulfil the social and economic needs of the farmers (Koome, 2017).

Underutilized cereals are crucial to the livelihood of thousands of resource-poor farmers all over the world. Tadele (2019) stated that these cereals provide more nutrients than that food that dominated global production. Also, he states that sorghum contains a high amount of zinc, potassium, magnesium, vitamins and calcium iron that are essential for human consumption (especially for children, expecting and nursing mothers), is also utilised as fodder and feed grain for livestock. The sorghum seeds have a low glycaemic index and slow digestion hence commonly used by diabetes patients. Besides, sorghum is considered a healthy food since the grains contain gluten, the cause of celiac disease.

Nevertheless, major challenges are limiting the productivity of these underutilized cereals; labour intensive, low yield and marketing (Jerop *et al.*, 2018). On the other hand, consumers and most farmers are utilizing these crops less because they are not competitive with other crops in the same agricultural environment (Pingali, 2012). The viability of promoting underutilized crops is depended on how they are produced and marketed together with acknowledging niche potential and the role of innovations. Due to increased health awareness, there is a gradual increase in the use of sorghum products as shown by the quantity produced and range of processed these products sold in the resident supermarkets (Kilambya & Witwer, 2013), hence the change in consumption patterns increase demand for the underutilized crops. In

regards to these, there is a need for the government and developing partners to come up with policies that promote the development of a competitive intra rural market for sorghum to encourage producer farmers to increase production (Mukarumbwa & Mushunje, 2010). Also, the development of these markets will be a great incentive and impactful for these sorghum farmers in the semi-arid areas, hence they will produce for their consumption and as a cash crop to meet their financial demand.

Sorghum consumption is said to be concentrated in areas of sorghum production (Proietti *et al.,* 2015) local consumption and being added value to produce other products like beer by malting companies. By contrast, consumer demand for maize is more evenly spread. But sorghum in Kenya and Tanzania are widely characterized by high levels of urban consumption. Schipmann-Schwarze *et al.* (2012) added that these staple crops are largely self-consumed with only about 30% of the product being marketed in the local and urban markets.

A report by USAID (2017) on staple food value chain analysis states that sorghum utilization is based on feed, seed, processing, and waste and as food (both grain and flour). Whereas Schipmann-Schwarze *et al.* (2012), noted that market channels for sorghum are varied and include direct sales to final buyers and sales in retail markets, sales to wholesale markets or urban traders or to visiting traders in the villages are lower. Most sorghum production units are small family farms with limited capital and asset base.

## 2.2 Farmers' innovative capabilities

Drucker (1985) views innovation as a means to give the resource a new ability to create wealth for different agrienterprises. Innovation is becoming inevitable in the agriculture sectors worldwide since it helps meet the food security demand as well as sustainable agriculture to countries' economies (Walder *et al.,* 2019). Innovative capabilities play a critical role in the study of innovation (Martinez-Roman *et al.,* 2011), and is important in providing and sustaining its competitive advantage (Akman & Yilmaz, 2008). According to Saunila *et al.* (2014), an innovative capability is defined as a capability an important factor that facilitates an innovative organizational culture, the characteristic of internal promoting activities and the capabilities of understanding and responding appropriately to the external environment. Olsson *et al.* (2010) describe an agrienterprises' innovative capability as the ability to develop innovations continuously as a response to a changing environment.

Moreover, increasing farmers investment support, education, learning and training on the best agriculture practises is has been identified as vital for the innovativeness of agriprenuers (Long *et al.,* 2016). Agrienterprises with innovative capability is likely to promote their farm performances (Amin *et al.,* 2016). Enterprises are urged to focus over on refinements in innovativeness to elevate agrienterprises performances (Udriyah *et al.,* 2019), therefore innovation contribute significantly to farm performances (Vazquez-avila, 2014)

In this study innovative capability is defined as the ability to develop a new product and /or market, through aligning strategic innovative orientation with innovation behaviours and processes (Wang &Ahmed, 2007). However, Martinez-Roman *et al. (*2011) split innovation capability into three factors: the human factor, knowledge and organization, all having a managerial point of view. Weerawardena (2003) categorized innovation capabilities into four, namely; managerial innovation, production innovation, marketing innovation, and process innovation. According to Saunila and Ukko (2011) categorise innovative capabilities into seven determinants: participatory leadership culture, ideation and organization structure, work climate and wellbeing, know-how development, regeneration, external knowledge and individual activity about an organization. Also, Wang and Ahmed (2007) identified five factors that contribute to an agrienterprises' overall innovativeness as a product, process, strategic, market and behavioural innovativeness.

In this study, Wang and Ahmed's (2007) point of interpretation is nearer to the direction of the research. Hence, innovative capabilities are categorised as developing a new product or service, developing a new method of producing, identifying a new market, discovering new sources of supply and developing new organizational forms. The degree of innovation ranges from incremental to radical innovations (Weerawardena, 2003). An incremental change builds on the existing set, whereas a radical innovation is said to mark a distinct and risky departure from the existing practise and competencies (Bhupendra & Sangle, 2015).

### 2.3 Factors influencing the use of innovation among smallholder agrienterprises

Universally, farmers face a lot of challenges in their agriculture practises and these include inaccessibility to quality farm inputs, appropriate agriculture technologies unpredicted climate and the suitable market for their produce. These challenges move farmers' decisions to grow crops and subsequently food production (Guti *et al.,* 2018). Most farmers in ASALs are

small scale involved in the production of subsistence crops of cereals like sorghum, pigeon pea, chickpea, millets and livestock keeping. Some of the challenges they face include high temperature, erratic rainfall, pest and diseases as well as lack of resources and information on farming strategies (Orr *et al.,* 2016).

The agriculture sector increasingly becomes information-dependent. Farmers need scientific and technical information for effective productivity. The concept of innovations and innovation systems have increasingly become common in the agriculture sector. The adoption of these innovations by farmers is greatly influenced by their character and the circumstances under which they operate (Kavoi *et al.,* 2017). Successful adoption of agricultural innovations by farmers not only depended on the planning and methodologies of research and extension programs but also the farm-household factors and critical external factors that are largely unpredictable (Guti *et al.,* 2018).

Various studies found that economic, technology, institution, household-specific and social factors influence the adoptions behaviour of different technologies. Economic factors including farm size, a net gain of the new technology, off-farm income may influence the uptake of the innovation or undermine (Mwangi & Kariuki, 2015; Perito *et al.,* 2017). On technological factors, Mignouna *et al.* (2011) and Wandji *et al.* (2012) argued that farmers perceive the technology as being consistent with their needs and compatible with their environment are likely to be adopted. On the other hand, farmers within a get informed, exchange ideas and learn from each other on the benefit and usage of new technology, hence social network is essential. In addition to institutional factors. Jerop *et al.* (2018) found that access to extension service and credit stimulates the adoption of innovation by small scale farm agrienterprises. Distance is also a key institutional factor. In developing countries, the distance to market places is an important factor for farmers in terms of product delivery (Maspaitella *et al.*, 2018; Mwangi & Kariuki, 2015). The human capital of farmers including age, gender, education level, household size is assumed to have a significant influence on farmers to adopt new technologies (Awazi & Tchamba 2018; Guti *et al.*, 2018; Jerop *et al.*, 2018; Mignouna 2014; Mwangi & Kariuki 2015).

Furthermore, Casolani, *et al.* (2019) also argues that innovative ideas are influenced by the environment where the agrienterprises is located. This is in line with the availability of resources, infrastructure, availability of resource person to help in implementing the ideas. Zheng and Shi (2018) also stated that the farm location can be categories into three types of factors:

firm attributes which entail development strategy type of ownership either owned or leased and the size of land, regional attributes which include the external economies of scale, market condition, and production factor price and government intervention such as tax competition and policies that government land and its productivity.

## 2.4 Role of innovation on the competitiveness of an agrienterprises

Innovations are considered critical in the agriculture sector, more so in countries where the sector contribute significantly to the development of its economic growth and livelihood of the majority of the population (Esparcia, 2013). They are seen to bring about productivity, competitiveness, quality and efficiency to farm agrienterprises (Mutsvangwa-Sammie *et al.*, 2017). Innovation definition varies because it ranges from the implementation of something new to improving products, processes, marketing or organizational methods. It focuses on the creation of a new product or service for customers allowing the farm agrienterprises to grow and increase the level of its profits (Gumbochuma, 2017) hence competitiveness. Also, innovation may take the form of improved and simplified techniques of farming, labour-saving technique, a means of helping an agripreneur improve the farm performance (Makate *et al.*, 2019)

According to Udriyah *et al.* (2019) innovation refers to a process of turning opportunity into a marketable idea. According to Lee and Hsieh (2010) innovation has two phases, invention and commercialization. Commercialization is to utilize new methods (invention) and the innovation process cannot be separated from business strategies and competitive environment. Hence there is a significant positive relationship between fam competitiveness and innovation (Aziz & Samad, 2016; Herman *et al.*, 2018). Innovation in small-scale farms can surpass in all areas from production, marketing, human capital and farm planning, but it only suits the specific needs of the agripreneurs at a specific time (Makate *et al.*, 2019).

However, this study focused on Production and market innovations as part of agriculture innovation used by farm agrienterprises. Bhupendra and Sangle (2015) defined production innovation as the novelty and meaningfulness of a new production method that improves the quality of the farm product. According to Herman *et al.* (2018), product innovation is one of the crucial factors to agrienterprises success and is a vital strategy for improving farm performance and increasing market share (Hassan *et al.*, 2013). Product innovation indicators are to develop attractive designs, develop good product quality for instant use of improved sorghum varieties

such as Seredo, Serena, Gadam and Kari Mtama 1 (Bosire, 2019) and development of product technology including agronomic practises.

On the other hand, market innovation is a new approach to exploring new markets and exploiting existing markets. Farmers uses of innovation is driven by the perception of their utility, either increasing yields, reducing risk, reducing the cost of production or increasing profitability (Mutsvangwa-Sammie *et at.*, 2017). Market innovations enable agriprenuers to the competitive price in the market places. Due to increased health awareness, there is a gradual increase in the use of sorghum products as reflected by the quantity and range of processed these products sold in the local supermarkets (Bosire, 2019; Kilambya & Witwer, 2019). In regards to these, there is a need for the government to come up with policies that favour the development of a competitive intra rural market for sorghum to encourage small scale farmers to increase production (Mukarumbwa & Mushunje, 2010).

Besides, the development of these markets will act as a great incentive for these farmers in the semi-arid areas, hence they will produce for their consummation and as a cash crop to meet their financial demand. Mwadalu and Mwangi (2003) stated that small grains like sorghum are thinly-traded due to low production volumes and poor marketing channels. Therefore, most farmers produce enough to meet their domestic requirements with a little surplus to sell. Conversely, Hamukwala (2010) added that lack of proper storage facilities, transportation, and lack of accurate and timely market information affects the marketing of the grains. Hence to use of market innovation will help sorghum agriprenuers to bridge this gap and increase their market share thus competitiveness.

Competitiveness, on the other hand, has been defined as the ability of agrienterprises concerned to produce and offer products that meet the quality standards of the market at prices that are satisfactory and provide sufficient returns on the resources used or consumed in using them (Gumbochuma, 2017). According to Tul-Krzyszczuk and Jankowski (2019), competitiveness means the ability to produce new goods and services, to achieve success in economic competition and to effectively develop in the long term. Whether measured by amount input or increase in the level of output, an increase in competitiveness requires, increased productivity, marketability and price received.

Furthermore, Njagi *et al.* (2019) stated that innovation leads to agrienterprises competitiveness and success. Drucker (1985) stated that innovation is an important tool of

agripreneurs in creating competitive potential in business and wealth by utilizing existing resources or by creating new ones, including the development of new knowledge. Virameteekul (2011) indicated that innovation can create sustainable growth that leads to a competitive advantage in both the internal and external markets. Also, Distanont and Khongmalai (2018) argue that innovation enables agrienterprises to present a new or improved product to the market before their competitors and thus increase their market share.

The African Competitiveness Report (2015) suggested the uses of the Global Competitiveness Index (GCI) to measure the competitiveness of a country. It defined competitiveness as a set of policies, factors and institutions that determined the level of productivity of a country. Gumbochuma (2017) stated two ways of measuring competitiveness. The first involves using comparative advantage indices, export or import indices and exchange rates to measure the trade-related competitiveness of a country. The second method applies to agrienterprises and this study, measures productivity, production cost, profitability and postharvest losses. It is based on the ability to reduce cost, increase input of productivity, levels of value chain, yields, unit prices and production output levels.

## 2.5 Role of sorghum value chains in the economy

Grain sorghum have multiple uses as compared to maize (Bolanle *et al.,* 2017). It has been noted that sorghum is one of the most important drought-tolerant crops that has the potential to surpass maize and wheat if proper mechanisms are put in place to address production and commercialization (Awazi & Tchamba 2018; Guti *et al.,* 2018. The production and release of new sorghum varieties by KALRO and Egerton University further compel the need for farmers to adopt sorghum as a high-value crop that has the potential to spur their income and food security needs (Fetene *et al.,* 2011). Also, due to health awareness and change of consumption patterns especially in the urban centres to the traditional crops, the demand for sorghum is increasing.

Furthermore, research evidence from government programs initiated in ASAL areas indicates that sorghum had the highest uptake and adaptability (Bosire, 2019; Orr *et al.,* 2020). In addition, the government's ASDS developed 2010 serves as a guide to Kenya's agricultural sector by supporting the promotion of agricultural productivity, commercialization, and raising the competitiveness of particular crop enterprises (Amadou *et al.,* 2011). The ASDS classifies

sorghum as one of Kenya's main food crops along with maize, beans, rice, wheat, potatoes, and vegetables. Before the establishment of the program, which runs until the year 2020, agricultural policies focused more on cash crops rather than staple food crops (Gok, 2010).

Kenya's strategic grain reserves have been increased over the years to an excess of over seven million bags of grain annually. These strategic reserve grains are inclusive of sorghum products (Anita *et al.,* 2019). In realizing the important role that indigenous crops play in alleviating extreme hunger, sorghum is one of the crops incorporated by the Ministry of Agriculture Livestock and Fisheries (Gok, 2010). Sorghum is considered a crop that does well across a range of agro-ecological zones in Kenya including the arid and semi-arid lands (Jerop *et al.,* 2018). The promotion of sorghum has been boosted by the release of high yielding and widely-adaptable varieties by various research institutions and seed companies. Policy initiatives, therefore, enhance the promotion of orphan crops as a solution to chronic food insecurity in ASAL regions (Tadele, 2019). The national food security and nutrition policy advocates for a healthy population that does not primarily depend on maize products but a variety of crop products through diversified eating habits (GoK, 2009).

The Kenyan government, through the Ministry of Agriculture Livestock and Fisheries (MoALF), embarked on a special program called *'njaa marufuku Kenya'* (NMK) that was intended to guide initiatives in improving food security (Auma & Mulonji, 2017). The program was developed in line with the United Nation's SDGs whose objectives were to halve hunger and poverty in Kenya by 2015 (Anita *et al.,* 2019). Kenya frequently receives 80% of famine alarms from ASAL areas which include the lower Eastern part of Kenya. One of the key strategies used by the government in the program was initiated the adoption of drought-tolerant crops by communities living in these regions (Anita *et al.*, 2019). Sorghum was adopted as an 'orphan crop' that could alleviate chronic food insecurity in the ASALs (Orr *et al.*, 2020; Tadele, 2014). 'Orphan crops' are crops that are typically not traded internationally but can play a critical role in regional food security (Tadele, 2019).

Small grains such as sorghum is considered more advantageous as compared to large grains such as maize (Schipmann-Schwarze *et al.,* 2013). This is because small quantities of flour from sorghum can cook a whole meal whereas large quantities of maize flour are required to cook the same (Anita *et al.*, 2019). Also, a meal cooked from small grains satisfies the hunger for longer periods and gives more energy. Sorghum grains can be stored for longer periods for up

to five years as compared to other grains; local storage technologies are used to store sorghum whereas large-seeded grains require sophisticated and expensive technologies to store (Orr *et al.*, 2020). In terms of production, sorghum performs better in periods of low rainfall thus giving higher economic values as compared to other crops (Mukarumbwa & Mushunje, 2010).

In recent years, KALRO in collaboration with the EABL initiated the promotion of the use of high-quality sorghum varieties for beer production (Orr *et al.*, 2020). The development has led to the development of interest from farmers to engage in commercial production of sorghum which has a very high prospect of income generation (Jerop *et al.,* 2018). This initiative also led to the production of high-quality sorghum through bulking and distribution of seeds to farmers through the Traditional High-Value Crops program under the MoALF. This program aims to increase the production and consumption of drought-tolerant crops in Kenya's ASAL areas (Amadou *et al.*, 2011).

To address limited production and commercialization of sorghum as climate-smart crops, ICRISAT and Africa Harvest together with KALRO implemented projects in ASAL areas that harnessed uptake of the two crops (Anita *et al.,* 2019; Chimoita *et al.,* 2019). These projects were launched with the target of strengthening both sorghum value chains in ASAL areas. Other dryland crops supported by the initiatives were cowpeas, pigeon peas, and green grams. Through these initiatives, drought-tolerant and high yielding sorghum seed varieties were released to farmers. Some of the improved sorghum seeds include Gadam, Sila, Andivanta, KARI Mtama 1, Serena, Seredo among others (Bosire, 2019)

In terms of industrial use, sorghum can be commercially processed into value-added products for export with prospects of earning the country foreign exchange (Anita *et al.*, 2019; Kaminski, 2013). Both white and red sorghum has the potential to be processed into malt and flour respectively by manufacturing companies. Products obtained from the processing of sorghum may form part of raw materials to be used in the manufacture of other products such as wine and animal feed or be readily available in the form of flour to cook porridge (Tadele 2019). On the other hand, products from the processing of sorghum also may play the same role of enhancing the manufacture of other industrial products or be readily used in the cooking of porridge, "ugali pap" and other ready food substances (Mukarumbwa & Mushunje, 2010).

Sorghum has been noted as staple food grain in many semi-arid and tropical regions of the world particularly in sub-Saharan Africa because of their good adaptation to harsh environments and

their good production yields (Mukarumbwa & Mushunje, 2010). Sorghum is generally the most drought-tolerant cereal grain crop that requires little input during growth and with increasing world population and decreasing water supplies, they represent important crops for future human use (Orr *et al.*, 2020). The semi-arid areas are characterized by unpredictable weather, nutrient-poor soils, limited and erratic rainfall and suffering from a host of other agriculture constraints (Bhagavatula *et al.*, 2013). Therefore, there is an urgent need to focus on improving crops relevant to the smallholder farmers and poor consumers in developing countries of the semi-arid areas (Tadele 2019). This can be through the promotion and development of crops that are adaptable to these environments Anita *et al.*, 2019.

That being the case, Anita *et al.* (2019) agree that sorghum has the potential to contribute towards the food security of many of the world's poorest and most food-insecure agro-ecological zones. This can be done through the promotion of new technologies like the use of improved seeds in increasing production and productivity (Orr *et al.*, 2020). of these crops in ASAL areas. Orr *et al.*, (2016), suggested that sorghum is one of the most critically important food security crops in ASAL areas. Their adaptability to light soils and lower rainfall makes them highly suitable when other crops are not feasible. The majority of the ASAL population depend on sorghum as the primary food source (Auma & Mulonji, 2017). Inadvertently, and owing to policy neglect and the resultant lack of incentives, these crops are produced in small quantities. Consequently, these crops remain largely subsistence with low yields, compounded by low market penetration as compared to maize and even wheat (Bolanle *et al.*, 2017).

## 2.6 Challenges and Opportunities in Sorghum Production

Major biotic imperatives for sorghum generation incorporate shoot fly, stem borer, head bug and aphid creepy crawly bothers; grain form, anthracnose infections, and leaf curse and weed competition and (in Africa) the parasitic plant Striga spp (Thakre, 2020). Major abiotic stresses are dry spells, tall temperatures, corrosive soils and moo soil ripeness. Bosire (2019) stated that nnumerous of these imperatives will encourage heightening with anticipated climate changes and will have indeed a more negative impact on efficiency, particularly dry spells and tall temperatures within the parched and semi-arid districts (Bolanle *et al.*, 2017). Changes in precipitation coupled with a rise in temperature with climate alter may decrease the length of the developing period (LGP) as decided by the term of soil water accessibility. In this manner, it'll

be critical that the maturities of crops match the periods of water accessibility to realize higher and steady yields.

Within the semi-arid tropics where sorghum is as of now developed amid the blustery season, the cruel crop-season temperatures are as of now near to or over these ideal temperatures. However, increased carbon dioxide concentration within the air 0seems to have useful impacts on trim development, and might somewhat invalidate the inconvenient impacts of rising temperatures depending on the degree of the temperature rise, and the degree of edit transpiration diminishments beneath lifted carbon dioxide. Based on the meta-data examination, Knox *et al.* (2012) evaluated the effect of anticipated climate alter by 2050s on sorghum efficiency for both Africa and South Asia. They detailed a 15% diminish in sorghum surrender over Africa and 11% over South Asia. Subsequently, suitable technologies ought to be created and actualized to manage up with future changes in climate within the creating countries.

To make sorghum competitive it is fundamental to progress their efficiency with guaranteed quality of the grain (Anita *et al.*, 2019). The zone beneath sorghum will not increment essentially unless the efficiency of the grain is made strides significantly. Therefore, there's a pressing need to progress the generation innovations for these grains and to spread this knowledge to the farmers' areas. According to Chimoita *et al.* (2019) recognizing a couple of well-researched elective employments for sorghum would abdicate unused roads for expanded utilization and hence act as a catalyst to make strides in generation and efficiency.

Sorghum can be used for other nourishment items by utilizing fitting preparation strategies (Bosire, 2019). Dehulling and processing hone to progress the quality of nourishments made from sorghum have been considered. It may be conceivable to choose grain sorts with progressed processing quality that will make these crops competitive with other cereals in terms of utilization. Wheat processing innovation with appropriate adjustment can be viably utilized for pounding sorghum. Even though bread can be created from entire sorghum flour, the quality of the bread can be made strides by utilizing sorghum flour from which the bran division has been evacuated by entry through sifters (Duoduet *et al.*, 2020). It is reported that sorghum malt may be utilized to create rolls, weaning nourishments and lager wort. Expansion of up to 40 per cent sorghum malt in rolls caused diminishment in stack stature and increment in spread since of expanded water retention (Orr *et al.*, 2016).

## 2.7 Theoretical and Conceptual Framework

There are several theories on innovations uptake by agrienterprises. Some of these theories include disruptive innovation, Henderson- Clark Model and Diffusion of Innovation. According to Clayton Christensen (Pandit *et al.*, 2018), disruptive innovations are innovations that create new market and value networks, and in due course disrupt the current market and value network over some time, leading to the displacement of earlier innovations. His main focus was technological innovations and how new technologies surpassed seemingly superior technologies in a market. Henderson and Clark came up with types of frameworks (Albert & Siggelkow, 2021): Knowledge of the component and knowledge of the linkage between the components to explain the firm's ability to innovate and its circumstances surrounding innovations. The two differences between the two dimensions lead to four types of innovations: incremental. Radical, architectural and modular product innovations. The Henderson-Clark model only gives insights into the different types of innovations. On the other hand, Wandera (2020) stated that diffusion theory focuses on the factors that determine whether or not and at what pace, and innovation will be adopted by members of a particular culture. Therefore, this model provides a basis to understanding small scale sorghum agriprenuers especially in ASALs, how they perceive and adopt innovation into their agrienterprises.

### 2.7.1 Diffusion of Innovation Theory

Rogers' diffusion of innovation (DOI) theory is the most appropriate theory for investigating the adoption of innovation by small-scale agrienterprises. Rogers (1995) defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system. He suggested that the diffusion process comprises four elements, namely: innovation, communication channels, time and social system (Wandera, 2020).

The first element is innovation, it is defined as an idea, practice or project that is perceived as new by an agrienterprises or other units of adopters. The newness characteristics of adoption are related to knowledge, decision and persuasion of the innovation-decision process. Rogers added that uncertainty prevents the adoption of an innovation. Attributes of an innovation that adopters perceive to either be: complex that is difficult or easy to use; compatibility is

perceived as being consisting with existing practices or habits and routines; having a relative advantage over the current practices and trial-ability of the innovations

According to Rogers (2003) communication is the process in which participants create and share information to reach a mutual understanding. It occurs through channels between sources. A source is either an individual or an institution. A channel is a means by which a message gets from the source to the receiver. It consists of both mass media and interpersonal communication. Mass media include the use of radio, television or newspaper. Interpersonal channels are two-way communication between two or more individuals (Chege *et al.*, 2020). It is also a nonverbal observation and is an important influence in determining the speed and the shade of the diffusion process in the system. Peres *et al.* (2009) suggested two additional mechanisms for diffusion: signal and network externalities. Signals are defined as any market information other than personal recommendations used by an adopter to decide. Whereas, network externalities refer to the observation that the utility of some product or service that increase as more agrienterprises adopt the innovation.

According to Rogers (2003), the third dimension is the relative time of adopting innovation. He argues that time is determined by the degree of innovativeness of agrienterprises. Rogers classified members of a social system into five groups are Innovators, early adopters, early majority, late majority and laggards. From Rogers, innovators are willing to experience new ideas, they are prepared to cope with the risk of unprofitability and unsuccessful innovations. Early adopter's holder leadership positions in the society, hence as role models, their attitude and decision to adopt is very important. According to Chege *et al.* (2020), Rogers argues that albeit the early majority have a good relationship with other members of society, they do have the same leadership trait as early adopters. The late majority are said to be sceptical about innovation and its outcome, but they are driven by peer pressure and the economic necessity to adopt innovations. Laggards are conservative and most sceptical about innovations and change. Their interpersonal network seems to consist of other members of their social system.

The last element is the diffusion process is a social system. Rogers defines it as a set of interrelated units engaged in joint problems solving a common goal. Since the diffusion of innovation is taking place in a social system it is influenced by the social structure of the system.

The structure is the patterned arrangement of the units in the system. He further argued that these structures affect agrienterprises innovativeness, which is the basis for categorizing adopters.

### 2.7.2 Conceptual Framework

In order to understand how particular variables in this study connect with each other, a conceptual framework is defined and illustrated. The conceptual framework shows the link between the socio-economic, institutional factors and innovative capabilities that influence the used production and market innovations consequently affecting the competitiveness of small-scale agrienterprises as shown in Figure 2. 1. Evaluation of the use of production and market innovations and the effect of the use of these innovations on the share of sorghum sold is vital in guiding efforts aimed at promoting these innovations, hence giving the small-scale agrienterprises the competitive advantage in the market and thus improving their farm agrienterprises performance. Increased productivity and profitability as a measure of competitiveness increases small scale sorghum livelihood in the ASALs

Small-scale agrienterprises have distinct socio-economic characteristics which include; age, gender, years of schooling, household size, farm size, income, land ownership, years of experience as well as a share of farm business among others. These factors have some influence on the kind and number of innovations used by small-scale sorghum agrienterprises competitiveness. Institutional factors which include; access to credit facilities, access to market information, contract arrangement, group membership, proximity to the nearest market and average price of sorghum, also have some effects on the production and marketing innovations used and farm competitiveness. Innovative capabilities which include: product, process, strategic market and behavioural also have some effect on the innovation used by the small-scale agrienterprises. The moderating variable like policy and weather also influence the product and market innovation used by the sorghum agripreneurs. However, when a small-scale sorghum agrienterprises applies several product and market innovations in the enterprises, the farm performance is expected to change. The use of product and market innovation leads to a change in the level of competitiveness for a sorghum enterprise which eventually changes the performances of farm agrienterprises.

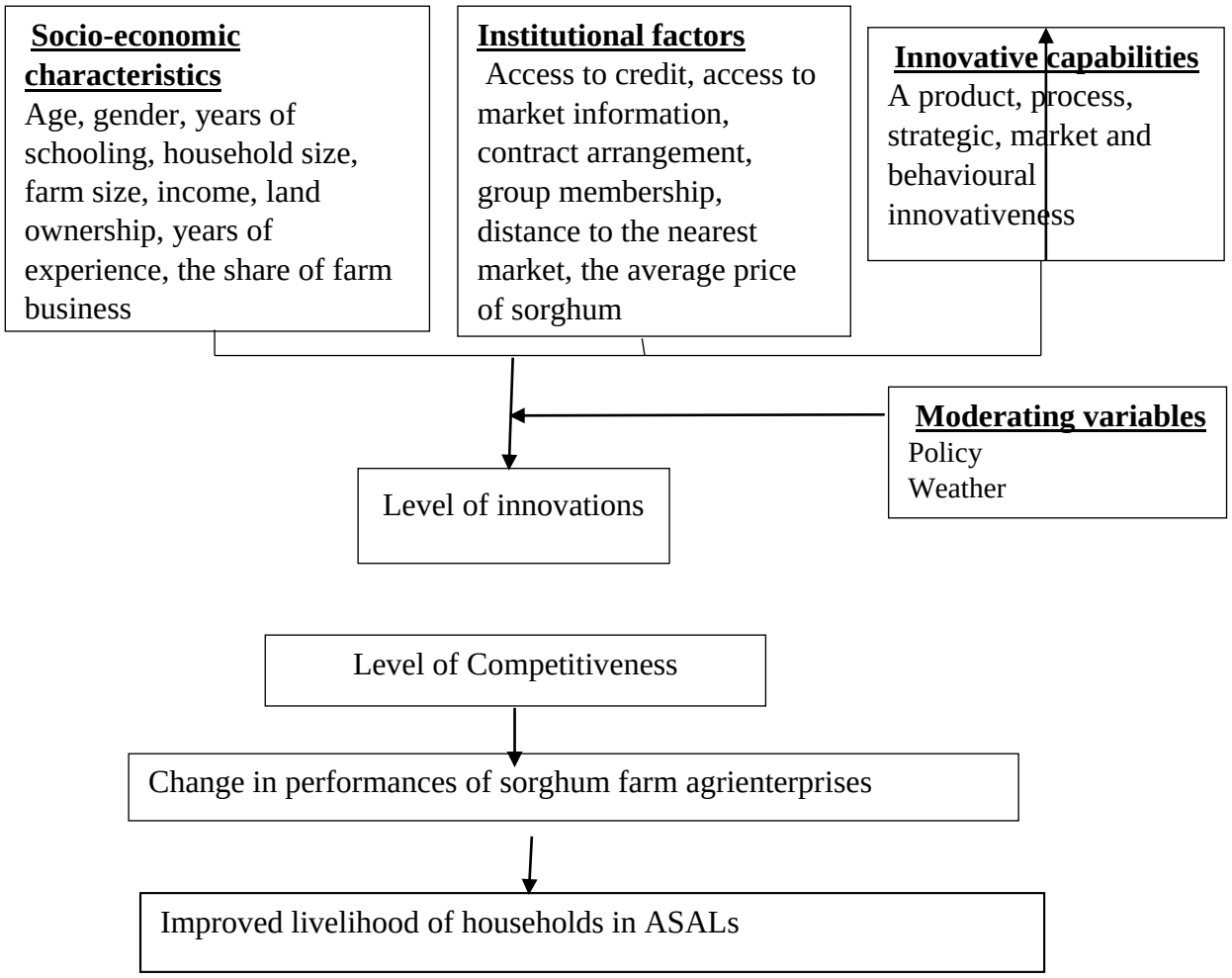


**Figure 2.1: Conceptual Framework**

# CHAPTER THREE
# METHODOLOGY

## 3.1 Study Area

This study was undertaken in Tharaka Nithi County of the Eastern region of Kenya. The County lies at the feet of Mt Kenya, covering approximately 266201 $Km^2$, including Mt Kenya forest which is estimated at 360$km^2$with a population of approximately 363,177 people comprising of male 49.3% and female 50.7% (KNBS, 2019). The County borders Meru to the North and North East, Kitui to the East and South East, Embu to the South and South West, Kirinyaga and Nyeri to the West and (Figure 3.1). The County lies between longitude 37$^o$ 19' and 37$^o$ 46' East and between latitude 000 07' and 000 26' South. The county receives bimodal and unreliable annual rainfall with an average of between 200mm and 800mm, but most parts of the county receive less than 750mm yearly.

The county has two main growing periods; the main season with long rains is from April to June and the short rains occur between the month of October to December with a total growing length of between 90-119 days. It has a mean temperature ranging between 11 $^0$C to 25.9 $^0$C during cold and hot seasons respectively. Mixed farming is one of the main economic activities of the areas, the livestock production is composed of indigenous species of Cattle, goats and chicken while most of the crop production is limited to rain-fed agriculture. However, the unreliability of rainfall increases major crop failures especially for maize (GoK, 2018). Tharaka County was selected because of its high potential in sorghum production. Also due to the presence of government and other stakeholders' intervention in promoting sorghum production and agrienterprises competitiveness to help improve the smallholder livelihoods through the use of innovations.

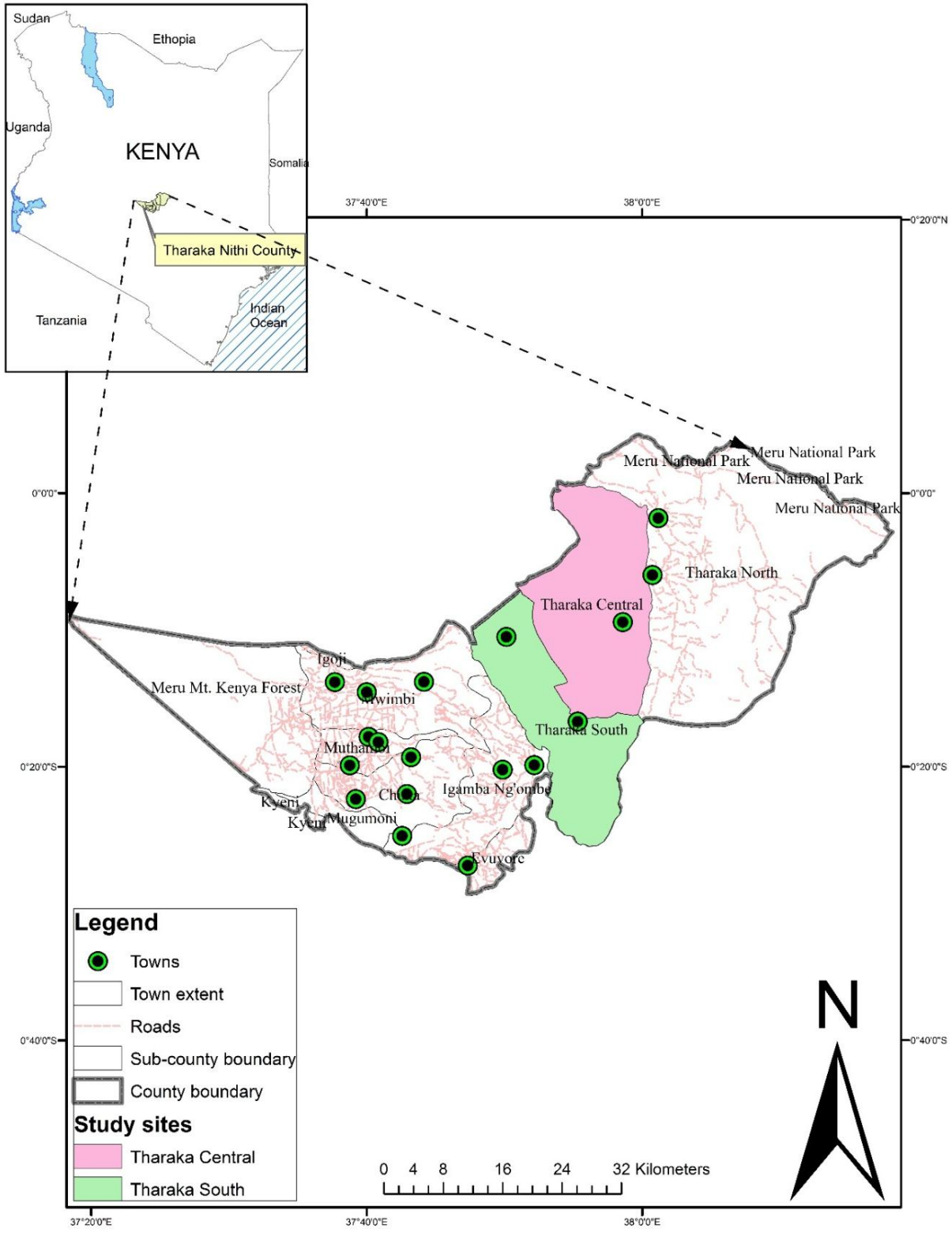


**Figure 3.1: Map of Tharaka Nithi County**

**Source: Geography Department, Egerton University, 2019**

### 3.2 Sampling design

A multistage sampling procedure was used to obtain 384 small scale farm agrienterprises to participate in the survey. The first stage involves a purposive selection of the Tharaka North and South sub-county due to its conducive ecological zone for sorghum production and also there are existences of various initiatives in the promoting production and usage of underutilized cereals to improve the livelihoods of the residents. The second stage involves a randomly selection of two wards, one from each sub-county, with the most extensive projects on sorghum production. The third stage is the random selection of villages. Finally, a simple random selection of 384 sorghum small scale farm agrienterprises was selected from the villages.

**Table 3.1: Distribution of the sample proportion to size of the sub-Counties population**

| Sub- County | Population | Proportion to size | Sample |
|---|---|---|---|
| Tharaka North | 58,252 | 0.44 | 168 |
| Tharaka South | 74,824 | 0.56 | 216 |
| **Total** | **133,076** | **1.00** | **384** |

### 3.3 Sample size determination

The required sample size of sorghum small scale agrienterprises was determined by Cochran (1977) formula.

Where;

$$n = \frac{Z^2 pq}{E^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

n=the desired sample size

Z =the standard deviation set using the desired confidence level (at 95% confidence level Z is 1.96)

P = proportion of the target population containing the major interest

q= 1-p and

E = the degree of accuracy desired in the study is 95%

$$n = \frac{1.96^2 \times 0.5 \times \left(1 - 0.5\right)}{0.05^2} = 384 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

### 3.4 Data collection

Primary data were collected from 384 farmers using semi-structured questionnaires ordered by trained enumerators. The data of importance include types of production and market innovations used by small scale agrienterprises, socioeconomic factors, institutional factors, innovative capabilities and the importance of these innovations of competitiveness of agrienterprises.

A pilot study was conducted to pre-test the questionnaire for its validity before the actual data collection takes place. Purposive selection of Mukothima Ward was done and 25 respondents were selected for the study.

### 3.5 Analytical framework

**Objective one: To examine production and market innovations used by small scale farm agrienterprises among small-scale agriprenuers.**

To identify the different products and market innovations used by small scale farm agrienterprises in Tharaka Nithi county, descriptive statistics were used. This entail use of frequency, percentages. The chi-square and t-test were used for comparison on the selected smallholder farmers and enterprises characteristics of the two group of farmers (users and non-users of innovations). The statistic describes and compares the different innovations used by small scale farm agrienterprises in Tharaka Nithi County. The results were presented in the form of tables.

**Objective Two: To examine the effects of farmers' innovative capability, socioeconomics and institutional characteristics on the level of use of production and market innovations among small-scale agriprenuers.**

To examine farmers' innovative capabilities, socioeconomics and institutional characteristics on the level of use of production and market innovations in Tharaka Nithi, the Poisson model was used. The level of use of production and market innovation was measured as the number of innovations used by the sorghum agrienterprises. The number of production and market innovation uses ($d_i$) represent count data and therefore count model was used. Count data allows the combination of categorical (uses product and market innovation or not) contrary

to probit and logit model was the dependent variable is a binary choice of whether to use of not and Tobit regression model which seizures the demand for these innovations.

The $d_i$ is drawn from a Poisson distribution with a parameter $\lambda_i$ that relates to regressors $x_i$ (Green, 2003), hence a Poisson regression model is expressed as;

$$prob(D_i = d_i \left| x_i \right.) = \frac{e^{-\lambda_i \lambda^{yi}}}{d_i}, d_i = 0,1,2,3,... \quad \text{(3)}$$

$y_i$ is a log-liner model defined as:

$$In\lambda_i = x_i^{'}\beta \quad \text{(4)}$$

The expected number of product and market innovation uses by an agrienterprises id given by:

$$E(d_i \left| x_i \right.) = Var(d_i \left| x_i \right.) = \lambda_i = e^{x_i^{'}\beta^{!}}$$

*or* (5)

$$\frac{\delta E(d_i \left| x_i \right.)}{\delta x_i} = \lambda_i \beta$$

However, the maximum likelihood technique can be used to estimate the Poisson regression model despite the model being a non-linear regression model (Green, 2002). Innovation employed by agrienterprises is an option, hence the number of innovations used by sorghum agrienterprises may not use then and thus the probability of excess zeros problem is high, limiting the usage of the standard Poisson model (Cameroon & Trivedi, 2005). Although Lambert (1992) suggested Zero-inflated Poisson (ZIP) as a solution to excess zeros, the regression become unsuitable in case the conditional variance exceeds conditional mean also referred to as over-dispersion. Hence, negative binomial (NB) regression was employed to deal with the over-dispersion problem. The NB model is specified as:

$$p(Y_i = y_i = \frac{\Gamma\left(y_i + \frac{1}{\alpha}\right)}{\Gamma(y_i + 1)\Gamma\left(\frac{1}{\alpha}\right)} \left(\frac{1}{1+\alpha\mu_i}\right)^{1/\alpha} \left(\frac{\alpha\mu_i}{1+\alpha\mu_i}\right)^{y_i} \quad \text{(6)}$$

$y_i = 0,1,2,3,....$

Where

$$\mu_i = \mathrm{E}(Y_i) = v_i \left[ e^{x_i' \beta} \right] = v_i \left[ e^{\sum_{j=1}^{k} x_{ij} \beta_j} \right] \quad \text{.....} \quad (7)$$

$i = 1, 2, 3, ..., n.$

And the variance of $y_i$ is

$$Var(Y_i) = \mu + \alpha \mu_i^2 \quad \text{.....} \quad (8)$$

The model variables, explanations and hypothesized relationships are shown in Table 1.

**Table 3.2: Description of variables to be included in the Poisson model**

| Variables | Descriptions | | Expected sign |
|---|---|---|---|
| **Dependent Variable** | | | |
| $y_i$ | Number of production and market innovations used | | |
| **Independent Variables** | | | |
| AgeHd | Age of household head (years) | Continuous | ± |
| GndKDM | Gender of the key decision-maker (1=male, 0=female) | dummy 1=male, o=female | ± |
| Nofschl | Number of years of formal school | Continuous | ± |
| NExpgSF | Years of experiences in growing sorghum | Continuous | + |
| HdSize | Number of household members | Continuous | ± |
| FarmSize | Total farm size | Continuous | ± |
| DistMkt | Proximity to the nearest retailing outlet (Kilometres) | Continuous | ±- |
| AvPSM | Average farm gate price of sorghum | Continuous | ± |
| SFshare | Share of sorghum sold/marketed | Continuous | ± |
| CreditA | Access to credit facilities | dummy 1=yes, 0=otherwise | + |
| MrtInfo | Access to market information | dummy 1=yes, 0=otherwise | + |
| Contr | Contract Arrangement | dummy 1=yes, 0=otherwise | + |
| FGrp | Membership of farmer groups | dummy 1=yes, 0=otherwise | ± |
| FC | Famers' capabilities (product, process, strategic, market and behavioural innovativeness) | PCA derive index continuous | ± |

**Objective three: To determine the role of production and market innovations on the level of competitiveness of sorghum small scale agriprenuers.**

From this objective, the interest lies on the causal effect of production and market innovation on the competitiveness of sorghum agrienterprises. Denoting agrienterprises by, $i$ and treatment (innovation) by, $t$, hence the possible outcome is denoted by, $y_{it}$. Let, $D_{it} \in \{0,1\}$, be

treatment indicator for each of the $T = 0, ...t$ treatment where, $D_{it} = 1$, for agrienterprises using innovation in their farms and, $D_{it} = 0$, otherwise, where of necessity, $\sum_{t=0}^{J} D_{it} = 1$, for all, $i$, sorghum agrienterprises. For each enterprise, there is a set of potential outcomes $(Y_{i0}, ..., Y_{ik})$. $Y_{it}$, denotes the outcome for each agrienterprises $i$ for which $T_i = t$ where, $t = \in \zeta = \{0, ..., k\}$. According to Rubin (1974), observed effect, $Y_i$, can be written in terms of treatment indicator, $D_t(T_i)$ hence potential outcome $Y_{it}$:

$$Y_i = \sum_{t=0}^{T} D_t(T_i) Y_{it} \quad \text{..... (9)}$$

Multiple treatments have no true counterfactual, hence it possible to estimated pairwise treatment between the different treatment unit's production $'p'$(production innovation) and $'m'$ (market innovation) (Lechner, 2001). Hence the outcome includes;

i. The average treatment effect of the treatment *p* relative to treatment *m*,

$$\tau^{pm} = \mathrm{E}\left[ Y_{ip} - Y_{im} \right] = \mu_p - \mu_m \quad \text{..... (10)}$$

ii. The average treatment effect for an agrienterprises from among the treatment group, *p*

$$\gamma^{pm/p} = \mathrm{E}\left[ Y_{ip} - Y_{im} \,/\, T_m = m \right] = \mu_{p/p} - \mu_{m/p} \quad \text{..... (11)}$$

iii. The symmetric treatment effect for the other treatment level *m*, that is, the average treatment of treated (ATT) with respect to treatment *m*,

$$\tau^{p/m} = -\tau^{m/p} \quad \text{..... (12)}$$

iv. The average treatment effect (ATE) of treatment *'p'* with respect to treatment *m'* on the subpopulation of the unit under treatment *'m'* is:

$$-\tau^{mp/m} \quad \text{..... (13)}$$

The potential outcome assumption framework for binary treatment unit is re-expressed to multiple treatment units. Thus, the condition independence (CIA) assumption and overlap form the basis for causal effect estimation in this model, extended as the general propensity score

(GPS). The GPS is the positive probability of receiving a treatment level given the condition variable (Adeyemo *et al.,* 2018)

$$r(t,x) = \Pr\left[T_I = t \middle| X_I = x\right] = \mathrm{E}\left[D_{it}(T_i) \middle| X_i = x\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

From Davidian *et al.* (2018) the potential outcome means can, therefore, be determined by weighting the observed outcome of the treatment with the estimated GPS weights given as

$$\mathrm{E}(Y_{it}) = \left[\frac{Y_i D_{it}(T_i)}{r(t, X_i)}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

Where $r(t, X_i) > 0$

The overlap assumption is taken into consideration with condition independences to form strong Ignorability (Rossembaum & Rubin, 1983), which is a complete overlap in the distribution of covariance between the treatment levels (Linden *et al.,* 2016). Established from notation assumption, there are approaches to estimating treatment effects in multivalued. This included Regression Adjustment (RA) estimator, Inverse Probability weighting (IPW) and doubly robust estimators (DRE).

The RA estimators are used in case of weak unconfoundness, the regression model is used to calculate the potential outcome after adjusting the $X_i$ for covariates which are assumed to have the confounders in the study the make inference unbiased. The RA fits separate lines for regression function for users and non-users, with different effects on profitability and productivity.

According to Funk *et al.* (2011), RA cannot only use the sampled mean profits and productivity of the agrienterprises output on innovation users and non-users to estimate the effect of innovation on the agrienterprises competitiveness. IPW on the other hand, is a treatment-effect estimator that applies the use of a weighted average instead of an unweighted average to separate the effects of the treatment on other confounders like the level of education. The probabilities are attained by fitting a model of treatment status on the characteristics of each theme. Hence the utility of IPW is depended on how the treatment model predicts the probability of the treatment.

IPW has limited to positive probabilities only also the overlap concept and because it uses weighted means to obtain potential outcome means (POMs) and ATE.

According to Wang *et al.* (2017), DRE includes the augmented inverse probability weighted (AIPW) estimators and the inverse probability weighted regression adjustment (IPWRA) estimator. The two estimator combines elements of the RA and IPW estimators to be more robust to misspecifications. The AIPW estimator combines IPW with augmentation term which helps to correct treatment model misspecification. Like IPW, AIPW does not give good results when the forecast treatment probabilities are near zero or one (Linden *et al.,* 2016). Therefore, the IPRWA estimator is an RA estimator that uses estimated inverse probability weights to precise the estimator when the regression model is mis specified. Thus, the weight will not affect the consistency of the estimator when the model is correctly specified.

The multivariate treatment effect mode specification to estimate the joint effects among different production and market innovations can be written as;

$$\Pr ob(y_i = 1 | t_i, x_i) = \Lambda(t_{Ai}\gamma_A + t_{Bi}\gamma_B + t_{Ai}t_{Bi}\gamma_{AB} + x_i\beta) \ldots\ldots\ldots\ldots\ldots\ldots \quad (16)$$

$y_i$ - represent the effect of production and market innovations on the competitiveness of an agrienterprises

$t_{Ai}$ - represent the number of production innovation used by the agrienterprises

$t_{Bi}$ - represent the number of market innovation used by the agrienterprises

$x_i$ - represent the list of control variables

$\gamma_A$ - is the independent treatment effect of production innovation

$\gamma_B$ - is the independent treatment effect of market innovation

$\gamma_{AB}$ - the interaction treatment of production and market innovation

$\beta$ - is the regression coefficient for each of the control

**Table 3.3: Description of variables to be included in the multivariate treatment effect**

| Variables | Descriptions | | Expected sign |
|---|---|---|---|
| **Independent (Outcome) variable** | | | |
| profitability | Gross margins from sorghum agrienterprises per ha | | Continuous |
| Productivity | Quantity of sorghum produced per ha | | Continuo |
| **Independent Variables** | | | |
| AgeHd | Age of household head (years) | Continuous | ± |
| GndKDM | Gender of the key decision maker (1=male, 0=female) | dummy 1=male, o=female | ± |
| Nofschl | Number of years of formal school | Continuous | ± |
| NExpgSF | Years of experiences in growing sorghum | Continuous | + |
| HdSize | Number of household members | Continuous | ± |
| Farmsize | Total farm size | Continuous | ± |
| DistMkt | Proximity to the nearest retailing outlet (Kilometres) | Continuous | ±- |
| SFshare | Share of sorghum sold/marketed | Continuous | ± |
| AvPSM | Average farm gate price of sorghum | Continuous | ± |
| CreditA | Access to credit facilities | dummy 1=yes, 0=otherwise | + |
| MrktInfo | Access to market information | dummy 1=yes, 0=otherwise | + |
| Contr | Contract Arrangement | dummy 1=yes, 0=otherwise | + |
| FGrp | Membership of farmer groups | dummy 1=yes, 0=otherwise | ± |
| FC | Famers' capabilities (product, process, strategic, market and behavioural innovativeness) | PCA derive index continuous | ± |

# CHAPTER FOUR
# RESULTS AND DISCUSSIONS

This chapter presents results and discussion of the findings on the role of production and market innovations on the competitiveness of sorghum agri-enterprises in Tharaka Nithi County. Small-scale agriprenuers were sub-divided into users and non-users of production and market innovations. Type of innovations identified to be used sorghum agriprenuers include improved varieties of sorghum seeds, good agronomic practices, group marketing and capacity building of farmers.

## 4.1 Agrienterprises and sorghum agriprenuers characteristics

### 4.1.1 Innovations used in Sorghum agrienterprises

The results on the number of innovations uses were further categorized into 'users' of innovation for respondents with at least one innovation and 'non-users' for respondents with zero innovations. The two frequencies of the two categories of users, non-users of innovations and the type of innovations used by sorghum agrienterprises are presented in Table 3.1. The results show that the majority (80%) of sorghum agrienterprises use innovations in the farms, whereas 20% do not. For the users, some of the common innovations used by sorghum agrienterprises in the area include the use of sorghum improved varieties, good agronomic practices, group marketing and capacity building of farmers. From the study, 78% of the agrienterprises used improved sorghum varieties such as Gadam, Sila, Andivanta, and Kari Mtama 1 available and required in the market. Most of which sourced their improved sorghum seeds were EABL agents, local agro vet shops and through the KCEP Project.

**Table 4.1: Cross-tabulation of innovations used by sorghum enterprises**

| Variable | Description | Frequencies | Percentage |
|---|---|---|---|
| Innovations used | Non-users | 77 | 20.05 |
| | Users | 307 | 79.95 |
| Types of innovation used | Improved varieties of seed | 239 | 77.85 |
| | GAP (intercropping, conservation agriculture | 187 | 60.91 |
| | Group marketing | 44 | 14.33 |
| | Capacity building of farmers | 65 | 21.17 |

The second innovation was good agronomic practices (GAP) used by 61% of the agrienterprises. This includes intercropping and conservation tillage to improve their farm productivity and increase output. The area has two planting seasons, the short season from September to February and the long season starting from March to July. Most of which they rotate with legumes, grains and cereals such as green grams, cowpea, beans and even maize in the long season from March to July.

Finally, the group market was used by 14% of the sorghum agriprenuers, they aggregate their output in groups and sell to contracted agents or buyers in the areas, this enables the farmers to get the relatively best price with the quantities collected. Lastly, 21% of sorghum agrienterprises interviewed had received training from the MoALF in collaboration with NGOs, research institutions and private organizations, especially in the banking sector and agrochemicals sectors. This is to support farmers financially and the capacity to build on agrienterprises management.

### 4.1.2 Socio-economic characteristics of sorghum agrienterprises

Table 4.2 presents the results of mean age, schooling years, years of experience and sorghum agriprenuers' farm size. The average age of all sample sorghum agriprenuers users was 43 years same as innovation users while the mean age of non-users was 44 years. The association between users' age and innovation non-users age was statistically significant at 5 %. The non-users of sorghum innovation were slightly older by 1 year with their counterparts.

**Table 4.2: Mean age, schooling years, years of experiences and sorghum agriprenuers' farm size**

| | Users | | None Users | | | |
|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Error** | **Mean** | **Std. Error** | **Overall mean** | **t-value** |
| Age | 42.75 | 0.68 | 43.86 | 1.69 | 42.97 | -0.694** |
| Schooling years | 9.64 | 0.29 | 7.94 | 0.60 | 9.30 | 2.638** |
| Years of experiences | 8.55 | 0.49 | 12.78 | 1.57 | 9.41 | -3.41*** |
| Farm size (acres) | 3.44 | 0.13 | 2.59 | 0.21 | 3.28 | 2.97** |
| Distances to the nearest market (Km) | 1.57 | 0.08 | 1.35 | 0.21 | 1.54 | 1.039** |

Note: ***, ** imply significant at 1% and 5% level respectively. Std. Error stands for standard Error

This implies that older sorghum tends to have more experiences in sorghum farming and over the years they have experimented on different innovations introduced in the region, hence they can conclusively apply innovations that worked well for them. Nevertheless, the age of sorghum agriprenuers in the study area was within the age categorized as active and productive (Mmbando & Baiyegunhi, 2016).

The average years of schooling for all sampled sorghum agrienterprises were 9 years whereas that of innovation users was 10 years and non-users of innovations was 8 years. The differences in years of schooling between users and non-users of innovation were significant at 5%. Users of innovation have slightly more years of schooling as compared to their counterparts. This implies that more years of education, exposure to sorghum agriprenuers to several different innovations, its application and its benefits. Through this, agriprenuers can use the innovations exposed to effectively. The results concur with several studies, that suggests educated agriprenuers are alleged to have a higher capability to attain, infer and respond to information on available innovations. Jerop *et al.* (2018) found that educated agriprenuers are more likely to access information and guidance from extension providers which influence their usage of innovations.

The sorghum agriprenuers' years of experience were 9 years. Users of innovations had 8 years of experience which is less than 12 years of experience of non-users of innovations. The t-test results nevertheless show that the variance in years of experience between users and non-users was significant at 1%. This implies that non-users tend to be inflexible to innovations having been adopted earlier than users of innovations. This result is in line with studies such as that of Wabwile *et al.* (2016) in the effect of improved sweet potatoes varieties on household food security.

All sample sorghum agrienterprises had an average farm size of 3.3 acres. However, users had a relatedly big size of 3.4 acres as compared to non-users who had an average of 3 acres. There was a significant difference in farm size at 5%. The users of innovations had relatively large farm sizes possibly because they are able to devote part of the piece of land to try various innovations in their farms as compared to their counterparts who have relatively small pieces of farm size. The land is a critical factor of production to sorghum agriprenuers. Donkor *et al.* (2018) found that agriprenuers with large farm sizes can use more innovations especially the capital-intensive innovations

The distance to the nearest market covered by users of innovation is approximately 1.6Km while non-users is 1.4Km. The association between users and non-users was significantly different at 5%. This was intriguing since the distance covered by the user of innovation was slightly longer than what is covered by their counterpart. Distance from the farm gate to the next-door market is considered a key factor for accessing the market and also the condition of the road, thus a measure of operation cost (Wabwile *et al.*, 2016). Also, the location from the trading center is key since it plays a role of proxy for a potential market of farm inputs including outputs and vital information access on innovations to use in the agrienterprises. Despite this, there are possibilities that the users of innovation are primarily interested in better price thus profits for their quality and quantity produce, hence they could cover more distance to achieve it. Furthermore, possibly they would prefer to transport their produce to EABL agents rather than selling it at the farm gate to brokers.

### 4.1.3 Institutional characteristics of sorghum agriprenuers

Table 4.3 present the results of the access to market information, group participation, access to credit, the number of training attended, number of extension services and contract

arrangements. The users of innovation who had access to information on market and innovations were 75% while that of non-users was 56%. The chi-square results indicated that there was a significant difference between the user of innovation and non-users at a 5% level. The results indicate that users of innovation tend to be more inquisitive about the market behaviors, as this information could enlighten their decision of the number of innovations to invest in to achieve market demands. In addition, the sorghum agriprenuers who uses innovations accessed more information on market prices of inputs, outputs, reliable buyers, issues of innovation more than non-users of innovations. Market information is key to every agriprenuers as it helps in developing, assessing and even monitoring the progress of the agrienterprises (Okello, 2017)

Group participation enriches idea and information exchange, social capital allowing trust, resource mobilization and hence contribute positively and significantly to the uptake of innovations (Mwangi & Kariuki, 2015). Over half of the innovation users (51%) sampled, belonged to a group in contrast to 17% of the non-users. The relationship between the use of innovation and group participation was statistically significant at 1%. Hence it is evident that the use of production and market innovations in the agrienterprises is influenced by group membership. Group simply unite and help farmers obtain information or training on diverse agriculture innovations issues (Wabwile *et al.*, 2016) that influence the use of the innovation given to improve their farm performances.

**Table 4.3: Access to market information, group participation, access to credit, number of training attended, number of extension services and contract arrangement**

| Variable | Description | Innovation | | $Chi^2$ Value |
|---|---|---|---|---|
| | | Users | None Users | |
| Access to information | Yes | 74.27 | 55.84 | 10.061** |
| | No | 25.73 | 44.16 | |
| Group participation | Yes | 51.14 | 16.88 | 29.282*** |
| | No | 48.86 | 83.12 | |
| Access to credit | Yes | 15.31 | 6.49 | 4.087** |
| | No | 84.69 | 93.51 | |
| Contract arrangement | Yes | 6.51 | 2.60 | 1.749* |
| | No | 93.49 | 97.40 | |

Note: ***, **, *imply significant at 1%, 5% and 10% level respectively.

Access to credit services is a former implement in the development of any agripreneurial venture and thus stimulates growth. Of the users, 15% had accessed credit whereas 85% had no access to credit. It is evident that users accessed credit for more than non-users. The association between the users and non-users of innovation is statically significant at 5%. Credit access by agrienterprises promotes the use of risky innovations through relaxation of the liquidity constraint as an option of borrowing. With the availability of credit, sorghum agriprenuers have a better capacity to invest in various innovations. Credit also enables agriprenuers to purchase farm inputs such as improved sorghum seeds, agrochemicals, hire extra labor hence improving the farm's competitiveness (Gaiha & Mathur 2019).

The sources of agriculture information used by sorghum agriprenuers are presented in Figure 4.1. The results show that the main source of agriculture information for users is other farmers at 42% followed by sorghum agent/aggregators at 40%. Other organizations like government agents, NGOs and private organizations came third at 9% and mass media such as radio, television and phone at 9%. These results show that the majority of sorghum agriprenuers rely on their follows farmers and sorghum agents. This could possibly be due to proxy for ease of information access. Farmers are neighbors and friends hence they are easily and frequently accessible, on the other hand, the majority of sorghum agents/aggregators are either known by the farmers, stationed at a specific place or they can be contacted for any information or clarity of information. These channels of communication are a means to which agriprenuers receive information on innovations over time (Rogers, 1995). The communication channel consists of both interpersonal communication and mass media.

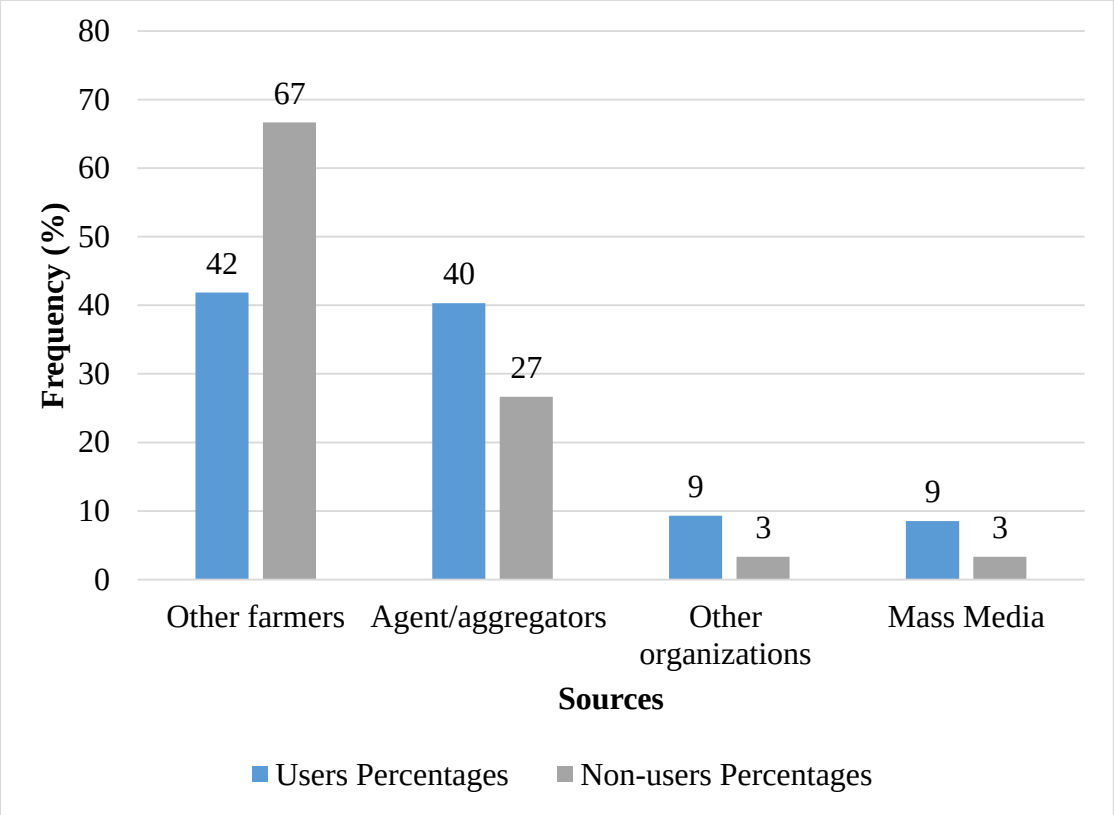


**Figure 4.1: Source of agriculture information**

Figure 4.2 presents results on the source of credit among sorghum agrienterprises. The main source of credit for sorghum agriprenuers was found to be grouped with 36% and 40% for users and non-users respectively, followed by SACCO with 28% for users, the others include banks at 15%, microfinance and friends and/or relatives both at 11% for users. This implies that the majority of sorghum agriprenuers are indebted to formal money lenders like SACCOs, micro finances and banks (53%) as compared to informal such farmer groups, friends and/or relatives (47%).

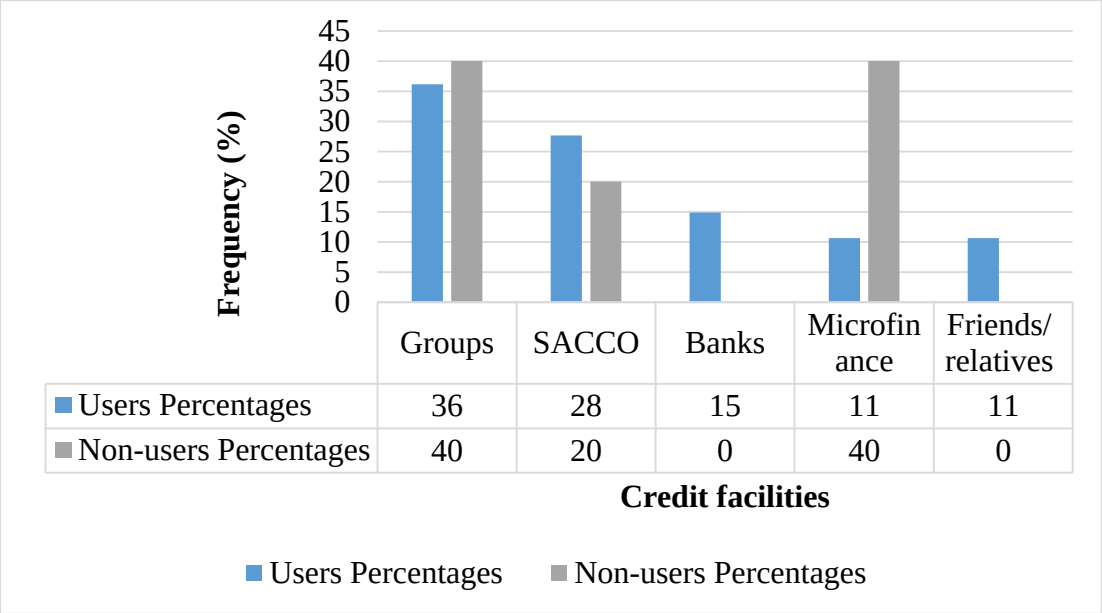


**Figure 4.2: Source of Credit**

The formal bank has the capacity to the lender a large sum of money, also with required documentation they are reliable. This result is consistent with Jeyakumar (2018) who found that farmers tend to buy more from the reliable and accessible formal sector as compared to the informal banking sector.

The results of main extension service providers are presented in Figure 4.3. The majority (46%) of users and 38% of non-users accessed the extension service from government officers, research organizations like ICRISAT and KALRO followed closely with 26% and 38% for users and non-users respectively. Also, 26% and 18% of the users' accessed extension services from farmer-to-farmer extension and other extensions respectively. Sorghum agriprenuers possible reach out more to government extension officers and research institutions because of reliability and vast kind of information for the source.

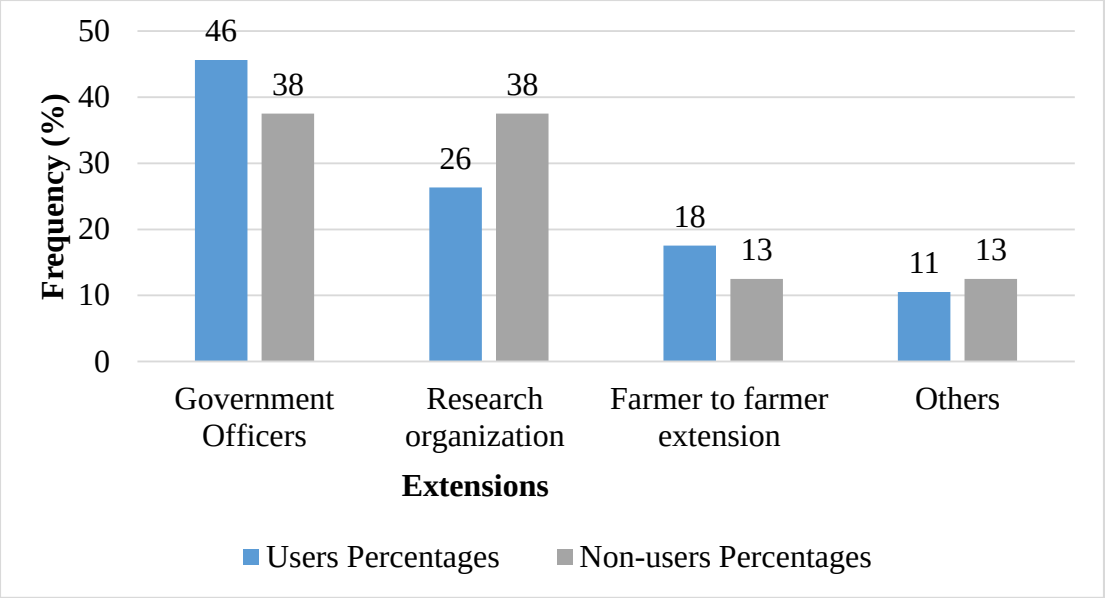


**Figure 4.3: Extension Service Providers**

Figure 4.4 presents results for the reasons for the choice of innovations by sorghum agrienterprises. The majority (83%) of the sorghum used the innovations in their farms because of the food yield from using and some from what they have witnessed in the neighbor's farms field days and demos. Similarly, 53% applied because of the easiness of applying, the innovations were not complex to them. Other reasons for the use of innovation included being supplied with the necessities to use like the KCEP projects and availability of extension officers to assist at 9% and 6% respectively. Hence agrienterprises are willing to use innovations introduced to them given their advantages and that the innovations should be friendly in terms of applicability.

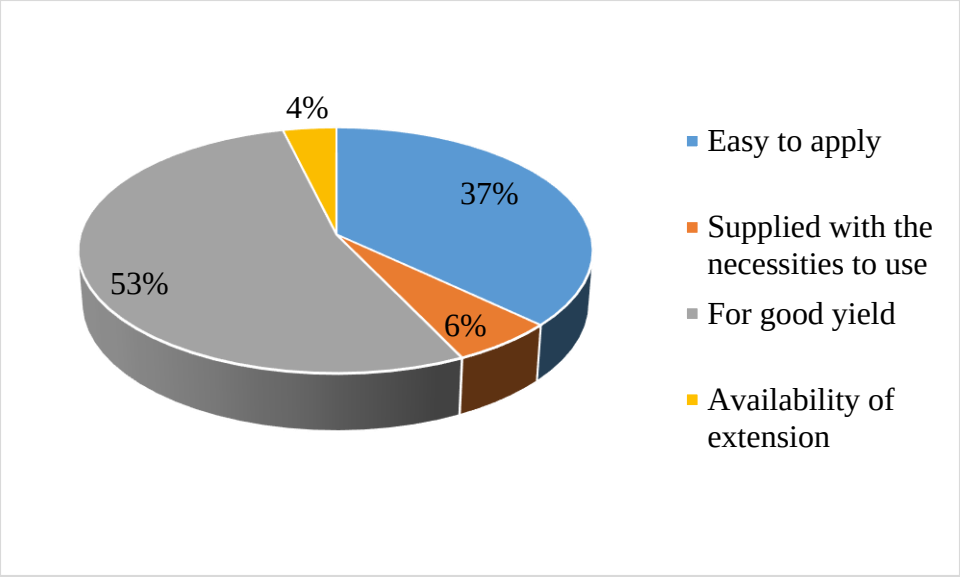


**Figure 4.4: Reason for the choice of innovation used**

Figure 4.5 shows the trainers of innovations to sorghum agriprenuers. Half (50%) of the interviewed sorghum agrienterprises received training on innovation from non-governmental organizations. Whereas 47% received the training from friends and neighbors, 42% were trained by government extension officers and the rest 11% of the trainers are research organizations. This implies NGOs are feasible in the region and this can do so because most of the NGO's project is implemented and innovation dissemination are done at group levels hence there are multiple effects. Also, agrienterprises tend to cop the innovations from their friends and/or neighbors' probability because of what they have seen in their friend's agrienterprises and the positive stories they share among each on the innovation. Government extension providers to are available and accessible in the area.

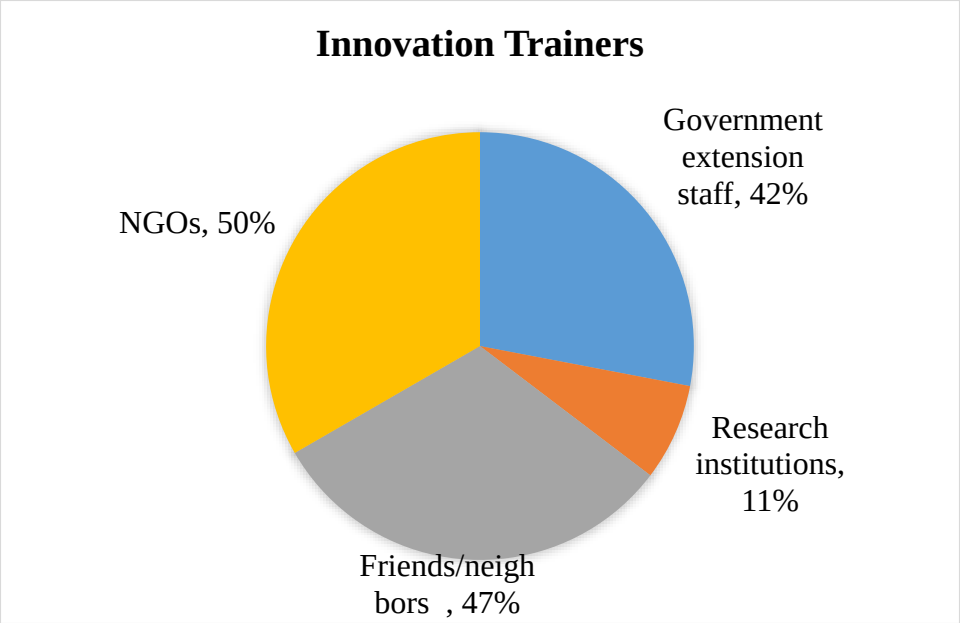


**Figure 4.5: Innovation Trainers**

Results of time taken to use innovation by the sorghum agrienterprises are presented in Figure 4.6. The results show that 36% and 31% of the sorghum agrienterprises take days and months respectively to use the innovations in their farms from the first time heard about it. From this, the majority (78%) take relatively short time days, weeks and even months as compared to 22% who take years. This can be attributed to the availability of extension providers and support they receive either from the NGOs, friends and/or neighbors. Agriprenuers gets to frequently use the innovations taught depending on the information and the availability of the trainer around.

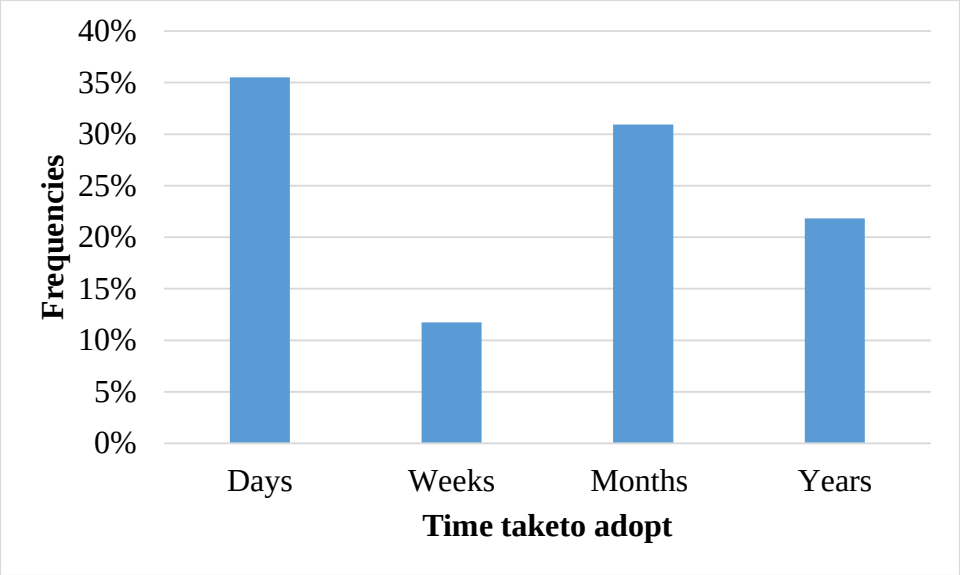


**Figure 4.6: Time taken to adopt sorghum innovation**

Figure 4.7 presents results on the frequency of use of the innovations. Half (52%) of the interviewed sorghum agriprenuers use the innovations often, 26% use it always. Besides that, 11% used it twice in a while and 10% use the innovations once in a while. This implies that sorghum agriprenuers in the region have been exposed to various innovations by the extension officer and developing partners and they have adopted them in their enterprises. Innovation is meant to lift agrienterprises from subsistence farming to a competitive advantageous level hence commercial practice. Thus, the more they use the better the performance of the sorghum enterprises in terms of operation and gross margins.

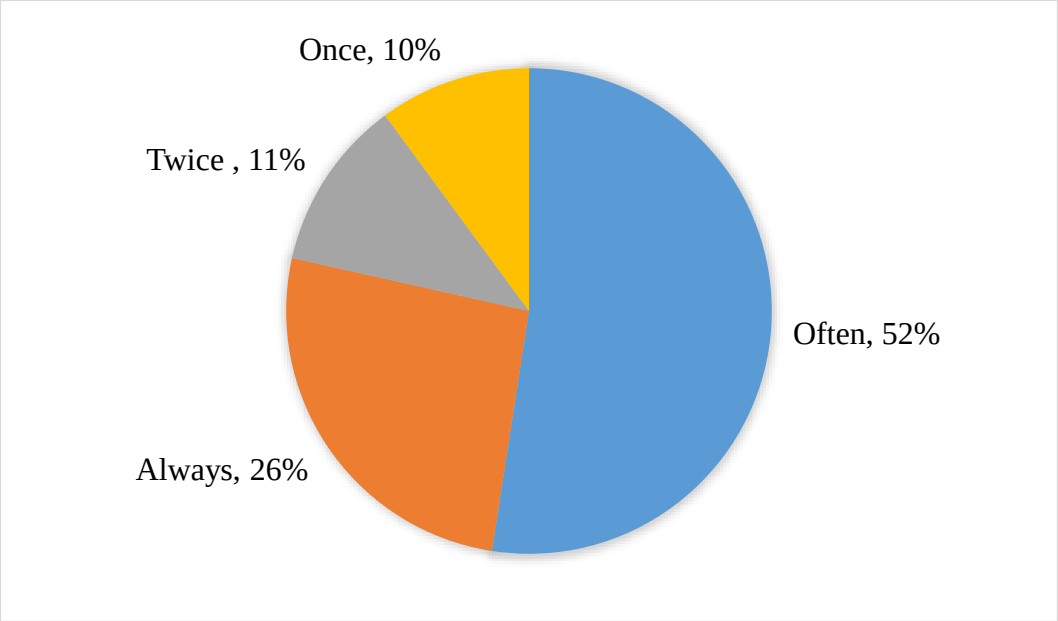


**Figure 4.7: Frequency of use**

### 4.1.4 Farmer's innovative capabilities

Tables 4.4 presented the results of Confirmatory Factor Analysis (CFA), which included factor loading, Cronbach alpha, Average Variance Extracted (AVE) and Kaiser-Meyer-Olkin (KMO) measure of sample adequacy. Five latent constructs were used to categorize farmers' innovative capabilities into product innovativeness, product innovativeness, strategic innovativeness, market innovativeness and behavioral innovativeness. A Likert scale was used to rank the descriptions to define weighted scores. The scale ran from 1-5 for the description's measurement (where 1 meant strongly disagree and 5 meant strongly agree). Kaiser's criterion for the determination of factors to retain was adopted. The factor loading documented values between 0.654 and 0.885 at a significance level of $p$=0.000. The factor loading values were above 0.5, hence justifiable enough to establish the least loading necessary to comprise construct (Sen & Antara 2018).

Cronbach alpha values were assessed to measure internal consistency reliability (CR). The alpha for the constructs documented values between 0.721 and 0.896 which demonstrated satisfactory indicators for reliability and convergent validity of the constructs (Gandhi *et al.*, 2019). All the latent variable recorded AVE values between 0.625 and 0.779 were above 0.5 thresholds, showing that each construct was highly related to its respective apart from product innovativeness with AVE of 0.454. The weak AVE value of product innovativeness is relieved by its CR of 0.75 and KMO of 0.756 which meets the threshold as recommended by Garson

(2016). KMO values for product innovativeness, process, strategic, market and behavioural innovativeness were 0.756, 0.862 0.500, 0.882 and 0.500 respectively. From KMO values, the overall adequacy of product innovativeness was middling, process and market innovativeness were meritorious and strategic and behavioural were unacceptable (Gandhi *et al.*, 2019). Therefore, for this study strategic innovativeness and behavioural innovativeness were dropped, product innovativeness, process innovativeness and market innovativeness were used.

**Table 4.4: Factor analysis of innovative capabilities**

| Variable | Items | Factor Loading | CR | AVE | KMO |
|---|---|---|---|---|---|
| Production innovativeness (Bhupendra & Sangle, 2015) | My agrienterprises' new products are often considered as very unique by customers | 0.657 | 0.750 | 0.454 | 0.756 |
| | My agrienterprises develop new product/service | 0.654 | | | |
| | In comparison to the competition, my agrienterprises have introduced more innovations in the past 5 years | 0.663 | | | |
| | My agrienterprises' recent new product is significantly different from previous productions | 0.772 | | | |
| | In comparison to the competition, my agrienterprises' production is successful | 0.815 | | | |
| Process innovativeness (Bhupendra & Sangle, 2015) | My agrienterprises have flexible production methods which can be changed efficiently | 0.844 | 0.873 | 0.754 | 0.862 |
| | My agrienterprises has focused on smart business processes upstage | 0.863 | | | |
| | My agrienterprises uses new delivery and distribution network | 0.810 | | | |
| | My agrienterprises invest in new techniques/ equipment to improve its activities | 0.778 | | | |
| | In the last 2 years, my agrienterprises' production method is better | 0.778 | | | |

Continuation of Table 4.4

| | | | | |
|---|---|---|---|---|
| Strategic innovativeness | My agrienterprises have a good range of product grades to suit the customer choice | 0.885 | 0.721 | 0 |
| (Bhupendra & Sangle, 2015) | In my agrienterprises, Key decision maker has abilities to simulate future market | 0.885 | | |
| Market innovativeness | New variety produce in my agrienterprises often take up against new competition | 0.830 | 0.896 | 0 |
| (Bhupendra & Sangle, 2015) | My agrienterprises marketing strategies are considered effective | 0.849 | | |
| | My agrienterprises involves its market partners when placing a new product in the market | 0.825 | | |
| | My agrienterprises produce products that address customer needs | 0.844 | | |
| | My agrienterprises explore new market avenues | 0.859 | | |
| Behavioural innovativeness | In my agrienterprises, while employing, ability to innovate is critically evaluated | 0.851 | 0.728 | 0 |
| (Bhupendra & Sangle, 2015) | My agrienterprises has a structured process to approve new ideas for implementation | 0.840 | | |
| | Innovative behaviors are rewarded often | 0.735 | | |

Note: chi-square; *df;* p-value=0.000; CR: composite reliability; AVE: average variance extracted; KMO: Kaisaer-Meiyer-Olkin

The weighted mean of the farmer's innovative capabilities is presented in Table 4.5. The Weighted Mean was used to engender the scores of products, innovativeness, process innovativeness and market innovativeness. The t-test statics was used to compare the weighted means of the users and non-users of innovations.

**Table 4.5: Mean Score of Farmer's innovative capabilities**

| Variables | Users | Non-users | t-test value |
|---|---|---|---|
| Product innovativeness | 3.58 | 3.03 | 5.85*** |
| Process innovativeness | 3.61 | 3.04 | 4.92*** |
| Market innovativeness | 3.60 | 3.07 | 4.53*** |

Note: ***, significant at 1%

As indicated in Table 4.5, farmers' product innovativeness, process and market innovativeness were all significantly different between users and non-users at a 1% significant level. The means score of users were as high as compared to non-users this shows that the innovative capabilities of a key aspect in the competitiveness of an agrienterprises. Innovative capabilities are a core skill for agrienterprises that help to attain competitive advantage. Innovativeness refers to the degree to which a farmer is responsive to innovations promoted or new ideas and decides to apply them (Singh, *et al.*, 2020). Furthermore, Olsson *et al.* (2010) describe an agrienterprises' innovative capability as the ability to develop innovations continuously as a response to a changing environment, hence sustainability of the agrienterprises. Hence, an increase in the innovativeness of agripreneurs is viewed to be a key enabler to develop value and respond to the market as well as customer needs and demand, thus this allows achieve suitable farm performances (Bamgbade *et al.*, 2017).

However, the innovative capabilities discussed in this study include product innovativeness, process innovativeness and market innovativeness. Product innovativeness refers to the uniqueness of a new product being introduced to the market in an apt time (Bamgbade, *et al.*, 2017). Product innovativeness is informed by the market demand for a new product or new form of an already existing product. Innovativeness in sorghum agrienterprises is more on producing newly introduced varieties to the market, the improved sorghum varieties developed by researchers. Such products tend to have relatively better

attributes in terms of productivity, resistance to pests and disease and a have a high demand for seed as while as the produce.

On the other hand, process innovativeness refers to the propensity and capacity of sorghum agrienterprises to be innovative in their production process to deliver quality and quantity production and attain a competitive edge within the market (Bamgbade *et al.*, 2017). It allows small-scale agriprenuers to meet the market demands in different ways, as it needs to understand the customers' needs and minimize loss from rejects. Some of the process innovations used include the use of good agronomic practices, conservation agriculture practices that enables agrienterprises to produce high volumes of agricultural produce to meet the buyers demand like the malting company EBL, which buys sorghum in tons (Njagi *et al.*, 2091).

Market innovativeness is the new tactic to explore new market opportunities and exploit the existing market channels available (Bhupendra & Sangle, 2015). Market innovation is also linked to product innovativeness since it also involves introducing a new product to the market. At the enterprises, increase market innovativeness enables the enterprises to be more aware of the new opportunities for better farm performance through the use of market channels (Micheels & Gow 2015). The ultimate goal of every agripreneur is to maximize profit either by reducing the cost of production or accessing a better market or price for their produce. An example of market innovativeness is contract farming. The contract arrangement between small-scale sorghum agrienterprises assures the market for the agriprenuers. It motivates a farmer to invest, produce quality and quantity produce since the prices are pre-determined and the market is readily available hence specified. Thus, the integration of innovative capabilities in agrienterprises is vital in the quest to realize the competitiveness of the farm.

## 4.2 Effects of farmers' characteristics on the level of use of innovation

Poisson model was used to analyses the farmers' innovative capabilities, socioeconomic and institutional characteristics on the level of use of production and market innovation among small-scale agriprenuers

### 4.2.1. Preliminary diagnostic of the variables to be used in econometric analysis

Preliminary diagnostic for statistical problems of multicollinearity and heteroskedastic were conducted to the explanatory variables used in the econometric analysis. A white test was used to ascertain heteroscedasticity and results were presented in Table 4.6. The results displayed presences of heteroskedasticity as a *chi*-square of 154.94 is significantly very large. This shows that the error term does not have a constant variance, hence to deal with this problem, the robust standard error was used in all econometric analyses.

**Table 4.6:** White test results for Heteroskedasticity

| **Source** | ***chi*$^2$** | **df** | **p-values** |
|---|---|---|---|
| Heteroskedasticity | 154.94 | 131 | 0.5191 |
| Skewness | 18.96 | 15 | 0.1180 |
| Kurtosis | 2.39 | 1 | 0.2138 |
| Total | 176.29 | 147 | 0.0871 |

Multicollinearity occurs when their high inter-correlation between independent variables, this was tested using pairwise correlation for categorical data and Variance inflation factor (VIF) for continuous variables. The results of the categorical variables are presented in Table 4.7. The results indicated that there is no serious linear relationship among the categorical variables since the pairwise correlation coefficients were less than 0.75.

**Table 4.7:** Pairwise correlation of categorical variables

| | Gender | Market information | Group participation | credit facility | Contract arrangement |
|---|---|---|---|---|---|
| Gender | 1 | | | | |
| Market information | -0.004 | 1 | | | |
| Group participation | -0.052 | 0.127 | 1 | | |
| credit facility | 0.051 | 0.022 | 0.199 | 1 | |
| Contract agreement | 0.042 | 0.085 | 0.164 | 0.099 | 1 |

For continuous variables, the results are presented in Table 4.8. In the same way, the results confirmed that there is no serious linear relationship between continuous variables as the VIF values were less than 10.

**Table 4.8:** Variance inflation factor test results for multicollinearity

| Variable | VIF | 1/VIF |
|---|---|---|
| Age | 1.76 | 0.568 |
| Household size | 1.24 | 0.808 |
| Years of schooling of the respondent | 1.39 | 0.720 |
| Years of experiences | 1.30 | 0.767 |
| Share of farm business | 1.46 | 0.683 |
| Market distances | 1.06 | 0.947 |
| Average farm gate price of sorghum | 1.09 | 0.920 |
| Product innovativeness | 2.91 | 0.344 |
| Process innovativeness | 3.69 | 0.271 |
| Market innovativeness | 3.90 | 0.257 |
| Mean | 1.98 | |

### 4.2.2. Effects of farmers' characteristics on the level of use of innovation

To examine the effects of farmers' innovative capabilities, socioeconomic and institution characteristics on the level of use of production and market innovations among small-scale agriprenuers Poisson model was used. The level of use of production and market innovation was measured as the number of innovations used represented as count data. The negative binomial (NB) regression results were not significant as indicated in Appendix 2 meaning there was no case of overdispersion thus Poisson model was appropriate. The log pseudo-likelihood for the fitted model was -503.62 and the model was found to be strongly significant at a 1% level with a Wald *Chi*-square value of 193.64 ($p$ = 0.000). Hence, the explanatory variables of farmers innovative capabilities, the socioeconomic and institutional characteristics are able to satisfactorily explain the level of use of production and market innovations. Coefficient estimate, robust standard errors and significances levels for the parameters of the Poisson regression model are presented in Table 4.9.

Results from the Poisson regression model in Table 4.9 indicated that the variable years of schooling is positive and significantly associated with the level of use of production and market innovations at a 5% significant level. This result implies that as sorghum agriprenuers add an extra year to their education, the probability of using production and market innovation increases by 2%. This result indicates that exposure to education enables individual agriprenuers to internalize information on the use of innovation and applies them to their enterprises. Education enhances the allocative ability of farmers by enabling think critically (Kapalasa Eliya *et al.*, 2019) and to seek advice and information from extension providers which influence the level of use of the innovation (Jerop *et al.*, 2019)

The household size of sorghum agrienterprises is positive and significant on the level of use of production and market innovations at 5% level. An additional member of the family is likely to increase the probability of adding more innovations by 3%. This could be due to the available labour supply and/or the pressure to produce more to cater to the essential needs of the family. Household size is a measure of available farmer labour (Mwangi & Kariuki, 2015) that an agrienterprises with a larger household size have better labor, capacity when using production

**Table 4.9:** Factors affecting the level of use of production and market innovations (Poisson Model)

| Factors | coefficient | RSE | p-value |
|---|---|---|---|
| ***Socio-economic factors*** | | | |
| Age | -0.002 | 0.003 | 0.538 |
| Gender | -0.964 | 0.088 | 0.273 |
| Schooling years | 0.017** | 0.008 | 0.030 |
| Household size | 0.033* | 0.017 | 0.059 |
| Farm size | 0.022 | 0.017 | 0.208 |
| Years of farm experiences | -0.011*** | 0.004 | 0.005 |
| Share of farm business | 0.019 | 0.157 | 0.903 |
| ***Institutional factors*** | | | |
| Market distance | 0.043* | 0.024 | 0.075 |
| Average price of sorghum | -0.005 | 0.005 | 0.286 |
| Access to market information | 0.266*** | 0.077 | 0.000 |
| Membership of farmer groups | 0.588*** | 0.070 | 0.000 |
| Access to credit facility | -0.041 | 0.097 | 0.672 |
| Contract arrangement | 0.197* | 0.109 | 0.071 |
| ***Famers' innovative capabilities*** | | | |
| Product innovativeness | 0.128* | 0.074 | 0.086 |
| Process innovativeness | 0.123** | 0.060 | 0.041 |
| Market innovativeness | 0.088 | 0.064 | 0.169 |
| Constant | -0.871 | 0.306 | 0.004 |
| | Number of observations = | | 384 |
| | Wald $Chi^2_{(15)}$ = | | 193.64 |
| | Pseudo $R^2$ = | | 0.6905 |
| | Log pseudo-likelihood = | | -503.245 |
| | Prob > $Chi^2$ = | | 0.0000 |

Note: ***, **, *, indicates significant level at 1%, 5% and 10% level, respectively.

and market innovations in the farm. Household size can also imply a demand for food and resource (Jerop *et al.,* 2019). Hence the sorghum agrienterprises seek to improve the farm performances by increasing the level of use of production and market innovations in their farms thus increasing income to meet the demands of the household.

Farming experiences of sorghum agriprenuers is negative and significantly associated with the level of use of product and market innovation at a 1% significant level. A one-year increase in farming years decreases the probability of use of production and market innovation by 1%. This may be due to the fact that older agripreneurs are the most experienced sorghum farmers. Hence this category of older agripreneurs may not see any reason to invest in product and market innovation again. Similar to Wabwile *et al.* (2016) as farmers with many years of use of innovations have already made up their minds on what they know about sorghum varieties and their production. The research also added that older farmers tend to be conservative in their styles of farming.

There was a positive and significant relationship between distances to the nearest market at 10% level. The results indicated that a 1 Kilometer increase in distance encourages the use of production and market innovations by 4%. Contrary to the norm, this could possibly be due to the entrepreneurial attitude. That since the sorghum agriprenuers have taken a step to invest in several innovations they would be willing to take an extra mile to search for better inputs, information or prices for their produce. Distance to the market enables sorghum agriprenuers to access information, farm inputs and market easily (Ouya *et al.,* 2019). Agrienterprises closer to the market is more likely to use more innovations because they do not have to travel long distance either to procure farm inputs or sell their output, hence they incur slight low transaction cost as compared to their counterparts (Kapalasa Eliya *et al.,* 2019).

Group participation is a positive and significant association with the level of production and market innovation used by sorghum agrienterprises at a 1% level. This result implies that farmer group participation increases the use of production and market innovations used because group collaboration and meeting, is a means to which extension delivery is a channel to farmers, participants get to exchange their ideas share knowledge and/or even discuss problems on-farm experience (Wekesa *et al.,* 2018). Farmer groups aid farmers to access credit and even farm inputs hence facilitating the use of innovations in the

agrienterprises (Debela *et al.*, 2018). The results, however, is contrary to Ahmed and Anang (2019) who found that farm groups do not influence the adoption decision of innovations of their members.

On the other hand, access to market information is negative and significantly related to the level of production and market innovation used at a 1% significance level. The results indicated that information from extension providers and training decrease the use of production and marketing innovations by 27%. The results raise some concerns on the accuracy reliability and consistency of market information received by sorghum agriprenuers (Mwangi & Kariuki 2015). The complexity of the use of innovation on the agrienterprises may decrease the use of innovations. As indicated in Figure 3.3 on the reasons for the choice's innovation used, sorghum agriprenuers tends to use innovation that is simply in terms of applicability. Hence information should be simple for farmers to understand, comprehend and utilize.

Contract arrangement between agrienterprises and buyers or agents was found to be positive and significant at a 10% significant level. This implies that an additional contract arrangement with buyers or agents will encourage sorghum agrienterprises to add innovation by 20%. The core objective of every agriprenuers is to get a good market for their produce and thus make a profit. Contract farming assures agrienterprises market for their produce. Hence agrienterprises will use innovations in their firm to ensure they produce the quality and quantity of sorghum required by the contractors and hence increase productivity and income to the agrienterprises (Bellemare & Novak, 2017)

Famers' innovative capabilities were positive and significantly associated with the level of use of production and market innovation for product innovativeness and market innovativeness at 10% significant level and process innovativeness at 5%. The results indicated that sorghum agripreneurs who apply product innovativeness were 13% more likely to use more product and market innovation in their enterprises. Product innovativeness implies producing unique or new varieties in the market hence this will be achieved through the use of product innovation. On the other hand, sorghum agripreneurs who have the process innovative capabilities, were likely to increase the number of product and market innovations in their enterprises by 12%. Process innovativeness involves smart farming methods that enable a sorghum agripreneur to deliver products that meet the market demand. The results

show that innovative capabilities play a significant role in the effectiveness of innovations in the firm. The existence of innovative capabilities enhances the competitiveness of agrienterprises (Najafi-Tavani *et al.*, 2018). Besides that, Sanjay *et al.* (2019) concluded that innovativeness demonstrated in the use of product and market innovations contributes to the sustainability of the agrienterprises and hence improve the livelihood of the farmers.

### 4.3 Role of innovations on the level of competitiveness of sorghum agriprenuers

To determine the role of production and market on the competitiveness of the sorghum agrienterprises Multivalued Treatment Effect (MTE) was used based on the assumptions of strong ignorability. Overlap assumption is graphically represented as the estimated probabilities of being assigned to a treatment unit (Appendix 3). The density illustrations that none of the treatment units have estimated probabilities at the extreme ends. The study, therefore, ascertains that the data gives unbiased inferences on the parameters of the treatment effects model estimated.

The competitiveness of agrienterprises was measured using the log of gross margin and productivity of the agrienterprises. The number of innovations used was used as the treatment units ($t$) which were 5 levels, with $t$=0, 1, 2, 3, 4; representing non-user of innovation, Low- level innovation users, middle-level innovation users, high-level innovation users and very high-level innovation users respectively The results showed that 20% of the respondents were non-users, 41% are low-level users, 25% were middle-level innovation users, 7% for both high and very high-level users of innovations as presented in Table 4.10. There were several innovations promoted by the MoALF as well as NGOs in the county. However, the results show that the majority (41%) of sorghum agrienterprises used at least one innovation on their farm. Therefore, cumulatively low uptake of the number of innovations used.

**Table 4.10:** Composition of sorghum agrienterprises Innovation Users.

| Variable | Description | Frequencies | Percentages |
|---|---|---|---|
| **Innovations Users** | Non-users | 77 | 20 |
| | Low-level users | 156 | 41 |
| | Middle-level Users | 96 | 25 |
| | High –level users | 27 | 7 |
| | Very high- level Users | 28 | 7 |
| **Total** | | 384 | 100 |

### 4.3.1 Mean potential outcome across the treatment effects

Estimates of potential outcome means (POM) of the log of gross margin for each of the treatment levels across the treatment effects (number of innovations) estimator used are presented in Table 4.11. The estimators across each level were found to be significant at a 1% significant level. RA estimators are said to be constrained by the specification of correct function forms (Adeyemo *et al.,* 2018) the estimator is the same as AIPW. However, IPW's violation of the overlap assumption chiefs biased estimates. Using the estimators from IPWRA, the potential outcome means of log gross margin are 9.3, 9.4, 9.5, 11.0 and 13.2 respectively for sorghum agrienterprises in non-users, low-level users, mid-level users, High-level users and very high-level users innovation users. The results depict a progressive an increase in gross margin with the increase in number of innovations used. This result is consistent with the study of Makate *et al*. (2019), that innovations have a positive effect on-farm productivity and profitability.

On the other hand, the average potential outcome of total sorghum harvested for the different innovation users using IPWRA is 845Kgs, 989Kgs, 1,265Kgs, 1,674Kgs and 1493Kgs for non-user, low-level users, mid-level users, high-level users and very high-level users respectively per acre. This result hypothesises a positive relationship between the number of production and market innovation used by an agrienterprises and competitiveness. There is an increase in both log of gross margins of the farm and productivity with increases in the number of innovations used on the farm. The results are in line with studies of Doris and Fiona (2018) and Makate *et al.* (2019). Despite the positive increase, there is a reduction

**Table 4.11:** Potential outcome means of the log of gross margin and farm productivity across treatment used and estimators.

| **Estimator/Treatment unit** | **Log Gross Margin** | | **Farm productivity** | |
|---|---|---|---|---|
| | **Parameter** | **RSE** | **Parameter** | **RSE** |
| ***RA*** | | | | |
| Non-Users | 9.184*** | 0.154 | 871.95*** | 88.760 |
| Low level Users | 9.404*** | 0.066 | 983.12*** | 71.803 |
| Mid-level Users | 9.545*** | 0.078 | 1263.19*** | 103.818 |
| High level Users | 10.863*** | 0.119 | 1468.65*** | 122.236 |
| Very high-level Users | 12.576*** | 0.946 | 1396.81*** | 311.933 |
| **IPW** | | | | |
| Non-Users | 9.310*** | 0.107 | 910.54*** | 86.241 |
| Low level Users | 9.422*** | 0.075 | 1000.79*** | 72.363 |
| Mid-level Users | 9.599*** | 0.082 | 1237.55*** | 88.960 |
| High level Users | 10.406*** | 0.131 | 1655.43*** | 125.170 |
| Very high-level Users | 10.246*** | 0.070 | 1466.336*** | 86.063 |
| ***IPWRA*** | | | | |
| Non-Users | 9.307*** | 0.169 | 844.96*** | 80.618 |
| Low level Users | 9.403*** | 0.065 | 989.17*** | 73.330 |
| Mid-level Users | 9.542*** | 0.077 | 1264.94*** | 109.514 |
| High level Users | 10.974*** | 0.167 | 1673.87*** | 303.153 |
| Very high-level Users | 13.201*** | 1.276 | 1493.32*** | 349.339 |
| ***AIPW*** | | | | |
| Non-Users | 9.184*** | 0.154 | 871.95*** | 88.760 |
| Low level Users | 9.404*** | 0066 | 983.12*** | 71.803 |
| Mid-level Users | 9.545*** | 0.078 | 1263.19*** | 103.818 |
| High level Users | 10.863*** | 0.119 | 1468.65*** | 122.236 |
| Very high-level Users | 12.576*** | 0.946 | 1396.81*** | 311.933 |

Note *** indicates a significant level at 1%

in both the log gross margin and farm productivity of the very high-level users. This is expected since the effect of innovation on competitiveness at the latter stage is tempered by saturation effects hence the decrease (Woo & Magee, 2017) in the competitive level of the agrienterprises.

### 4.3.2 Average treatment effects for the treatment estimators

Table 4.12 presents pairwise treatment effects for each group across treatment effects estimators. The double robust estimators, (AIPW) were discussed since they are consistently unbiased parameters even when the treatment or outcome model is not correctly specified (Linden *et al.*, 2016). If so, RA and IPW average treatment effect coefficients were found to be the same in terms of sign and direction of the effects.

**Table 4.12:** Treatment effects estimates across treatment effects estimators

| **Pairwise treatment effects** | **Log Gross Margin** | | **Farm productivity** | |
|---|---|---|---|---|
| | **(ATE)** | **RSE** | **ATE** | **RSE** |
| ***RA*** | | | | |
| Non-user→Low Level Users | 0.024 | 0.019 | 0.127 | 0.140 |
| Non-user→Mid-Level Users | 0.039** | 0.019 | 0.449** | 0.189 |
| Non-user→High Level Users | 0.183*** | 0.024 | 0.684*** | 0.220 |
| Non-user→Very High-Level Users | 0.369*** | 0.106 | 0.602 | 0.387 |
| Low Level Users →Mid-Level Users | 0.015 | 0.011 | 0.285** | 0.141 |
| Low Level Users →High-Level Users | 0.155*** | 0.015 | 0.494*** | 0.163 |
| Low Level Users →Very High-Level Users | 0.337** | 0.101 | 0.421 | 0.333 |
| Mid-Level Users →High-Level Users | 0.138 | 0.015 | 0.163 | 0.137 |
| Mid-Level Users →Very High-Level Users | 0.318*** | 0.099 | 0.106 | 0.262 |
| High Level Users →Very High-Level Users | 0.158*** | 0.087 | -0.049 | 0.227 |
| **IPW** | | | | |
| Non-user→Low Level Users | 0.012 | 0.014 | 0.099 | 0.131 |
| Non-user→Mid-Level Users | 0.031** | 0.015 | 0.359** | 0.160 |
| Non-user→High Level Users | 0.118*** | 0.019 | 0.818*** | 0.223 |
| Non-user→Very High-Level Users | 0.101*** | 0.014 | 0.610*** | 0.179 |
| Low Level Users →Mid-Level Users | 0.019 | 0.012 | 0.237* | 0.126 |

| | | | | |
|---|---|---|---|---|
| Low Level Users →High-Level Users | 0.104*** | 0.016 | 0.654*** | 0.172 |
| Low Level Users →Very High-Level Users | 0.087*** | 0.011 | 0.465*** | 0.136 |
| Mid-Level Users →High Level Users | 0.084*** | 0.016 | 0.338** | 0.135 |
| Mid-Level Users →Very High- Level Users | 0.067*** | 0.012 | 0.185* | 0.110 |
| High Level Users →Very High-Level Users | -0.015 | 0.014 | -0.114 | 0.083 |
| ***IPWRA*** | | | | |
| Non-user→Low Level Users | 0.025 | 0.023 | 0.265 | 0.167 |
| Non-user→Mid-Level Users | 0.033 | 0.024 | 0.504** | 0.223 |
| Non-user→High Level Users | 0.180*** | 0.031 | 1.279** | 0.499 |
| Non-user→Very High- Level Users | 0.456*** | 0.170 | 0.741 | 0.508 |
| Low Level Users →Mid-Level Users | 0.023 | 0.015 | 0.564** | 0.232 |
| Low Level Users →High -Level Users | 0.266*** | 0.037 | 1.257 | 0.798 |
| Low Level Users →Very High-Level Users | 0.488*** | 0.163 | 0.510 | 0.383 |
| Mid-Level Users →High Level Users | 0.238*** | 0.037 | 0.443 | 0.533 |
| Mid-Level Users →Very High-Level Users | 0.454*** | 0.157 | -0.035 | 0.272 |
| High Level Users →Very High-Level Users | 0.175 | 0.132 | -0.331 | 0.290 |
| ***AIPW*** | | | | |
| Non-user→Low Level Users | 0.012 | 0.020 | 0.178 | 0.142 |
| Non-user→Mid-Level Users | 0.027 | 0.020 | 0.507*** | 0.192 |
| Non-user→High Level Users | 0.181*** | 0.031 | 0.763*** | 0.263 |
| Non-user→Very High-Level Users | 0.451*** | 0.145 | 0.673* | 0.399 |
| Low Level Users →Mid-Level Users | 0.015 | 0.011 | 0.279* | 0.145 |
| Low Level Users →High Level Users | 0.167*** | 0.024 | 0.497** | 0.204 |
| Low Level Users →Very High -Level Users | 0.433*** | 0141 | 0.421 | 0.331 |
| Mid-Level Users →High Level Users | 0.149*** | 0.023 | 0.170 | 0.171 |
| Mid-Level Users →Very High -Level Users | 0.412*** | 0.139 | 0.111 | 0.263 |
| High Level Users →Very High-Level Users | 0.229** | 0.123 | -0.051 | 0.237 |

Note: ***, **, *, indicates significant level at 1%, 5% and 10% level, respectively.

The results show that for agrienterprises in the control group (non-users), there would be an increase in gross margin by 18% if they decide to move to high-level users and 45% if they decide to move to the highest level very high-level users at 1% significant level. Moreover, the result depicted that if sorghum agrienterprises with low-level users were to add innovation and move to high-level users their gross margin would increase by 17% and by 43% if they were to move to very high-level users. Agrienterprises at mid-level users would have their gross margin increased by 15% and 41% if they add more innovation to high-level users and very high-level users respectively. Lastly, agrienterprises in high-level users would increase their gross margin by 23% if they are to add innovation in their farms and move to the very high-level user at a 5% level of significance.

Furthermore, farm productivity increases as agrienterprises increase the number of innovations used and move from one level to the other as shown in Table 4.13. The results show a positive significant change in non-users and low-level users of innovation. There was a significant change at a 1% level of significance if an agrienterprises decides to move from low level to mid-level, its farm productivity would increase by 51%, it would further increase by 76% if low-level users decide to move to high-level. Moreover, if low-level users choose to move to the very high-level it would increase by 67% at a 10% level of significance. For Low-level users, the result depicted an increase of 28% if low-level innovation user chooses to move to mid-level users at a 10% level of significance, and a 50% increase if they decide to change to high-level users at 5%.
The findings point to the importance of production and market innovations by sorghum agrienterprises in the informal economy in the study area on their performances. The results indicated that there is a positive causal correlation between innovation and competitiveness of an agrienterprises (gross margins and farm productivity). Agriprenuers could be benefiting more as they move to the high level (number of innovations used in the farm). Therefore, production and market innovations play a role in running and agrienterprises since it helps in improving agrienterprises' profitability, productivity, and thus help achieve a competitive advantage (Gumbochuma, 2017; Läpple & Throne 2019; Makate *et al.*, 2019; Tul-Krzyszczuk & Jankowski, 2019) in the change agricultural economy. Hence, the small scale agrienterprises should be encouraged and provider with institutional support such as good infrastructure road network and information access, capacity building of group and formal or informal contract agreement with buyers or agents to aid the competitive level.

# CHAPTER FIVE
# CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

The general objective of the study was to contribute towards improved farm performances through enhanced competitiveness of small-scale sorghum agrienterprises by use of production and market innovations in Tharaka Nithi County, Kenya. The specific objectives of the study included; examining production and market innovations used by small scale farm agrienterprises. to examine the effects of farmers' innovative capability, socioeconomics and institutional characteristics on the level of use of production and market innovations among small scale agrienterprises to determine the effects of production and market innovations on the level of competitiveness of sorghum small scale agrienterprises. To attain these objectives data was collected through the use of the questionnaire. Moreover, descriptive statistics, the Poisson model and multivariate treatment effects were used to analyse the objectives respectively. The following three conclusions emerge from the analysis of the three objectives:

i) The results indicated agrienterprises are using more product innovation, improved seed variety and good agronomic practises perhaps to meet food production for subsistence. The finding of marketing innovations group marketing and capacity building were low.

ii) The study findings point out the connotation of socioeconomics, institutional characteristics and farmers' innovative capabilities as potential factors promoting the use of innovation in the agrienterprises. The results indicated that the likelihood of using more innovations was positively influenced by years of schooling, household size, market distance, access to information group participation, contract arrangement and innovativeness. Also, continuous improvement in the innovative capabilities will be fundamental in improving the agrienterprises competitive levels in future. This observation provides a wider range of interventions to improve agrienterprises performances.

iii) The vital findings are that the increased number of products and market innovations used have the potential to enhance agrienterprises competitiveness in terms of gross margin and farm productivity. Despite the positive results, at a very high level, the

high number of innovations users by an enterprise causes a saturation effect, leading to a decrease in the enterprises' performances.

## 5.2. Recommendations

From the findings of the study, the following are some of the recommendations that can be derived;

i) Tailor-make market innovations to suit small scall sorghum agrienterprises in ASALs. The contract farming between agrienterprises and buyers or agents is not fully utilized by small scale sorghum agrienterprises in the ASALs, there needs to further restructure and/or come up with other market innovations technologies to suit the sorghum agrienterprises in the ASALs. Furthermore, agrienterprises should be sensitized to incorporate many different production and market innovations in their farms to increase competitiveness. accordingly.

ii) Enhance farmers innovative capabilities. Innovativeness is important for farm performances, the task of policies makers and innovation development partners to design and implement an agrienterprises structure that embodies innovativeness. To enhance change in the performance of a farm, an agrienterprises must be formulated within a coordinated framework to ensure that operations reap the benefits of innovative capabilities.

## 5.3 Further Area of future research

The main focus of this study was to examine the role of production and market innovation on the competitiveness of sorghum agrienterprises, a similar study can be carried out to assess the effect of innovation on nutritional and income security in ASALs. The study was limited to product, process and market innovativeness, hence can be conducted while considering other components of innovative capabilities such as customers, behavioural and strategic innovativeness. There is also a need to analyse institution partnership that promotes agricultural innovations.

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## APPENDICES

### Appendix 1: Questionnaire

The purpose of this study is purely academic and more so to contribute to the understanding the role of production and market innovations on competitiveness of sorghum agrienterprises in Tharaka Nithi County, Kenya. Respondents are requested to **VOLUNTARILY** participate in answering this questionnaire and are assured that any information shared was strictly **CONFIDENTIAL.**

**GENERAL INFORMATION**

Date……County……. Sub-county……

Ward……..Village…….. (Phone No) ……

Name of the respondent ……..

**SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT**

**B1** Are you the head of the household ?..... *(Yes=1 No=2)*

**B2** If B1= No, What is your relationship to the household head *Tick appropriately)* 1= Spouse [ ]; 2= Child [ ]; 3= Parent [ ]; 4= Sibling [ ]; 5= In-law[ ] 6= None[ ]

**B3** Do you use the improved sorghum varieties? …… *(Yes=1 No=2)*

| **B4 .** Gender | | **B5 .** Age (Years) | | | | | | **B6** Marital Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M | F | <18 | 19-29 | 30-39 | 40-49 | 50-59 | >60 | Single | Married | Widowed | Divorced |
| | | | | | | | | | | | |

**B7** The number of schooling (years)……..

**B8** What is the education level of the household head? (*Tick appropriately)* 1= Not gone to school [ ]; 2= primary [ ]; 3= secondary [ ]; 4= college [ ]; 5= university [ ]

**ECONOMIC STATUS**

**C1.** Household size (*number of people living and eating in the hhousehold*) ……

**C2.** How many members contribute to the household income? ……

**C3.** What is the source of household income?

1=casual labour [ ]; 2=Salaried employed [ ]; 3=Business person [ ]; 4= farming [ ]

Others, Specify……..

**C4.** What is the estimated amount of income for the year (*in KES*)?

| | Source | Amount (Ksh) |
|---|---|---|
| 1. | Casual jobs | |
| 2. | Salary | |
| 3. | Business | |
| 4. | Sales of crops | |
| 5. | Sale of livestock and livestock produce | |
| 6. | Others, Specify | |

**FARM PRODUCTION**

**D1.** What is the size of land under sorghum (acres)

| Season | Acres |
|---|---|
| July/Dec 2018 | |
| Feb/June 2019 | |

**D2.** Indicate the land tenure system on the land in use and how you acquired it?

| **Total Size** | **Tenure System( Acres)** | | | |
|---|---|---|---|---|
| | **Owned** | **Rented in** | **Rented out** | **communal** |
| July/Dec 2018 Acres [ ] | | | | |
| Feb/June 2019 Acres [ ] | | | | |

**D3.** What is the total cost of producing sorghum in one acre? (*Kindly fill the table)*

| Activity | | Unit of measurement *(1= acres, 2=man-days, 3=Tractor, 4=Season 5=Kgs, 6= specify others)* | Total Number/Units | Cost per unit |
|---|---|---|---|---|
| Cost of leasing land | | | | |
| Land preparation | 1st clearing | | | |
| | Ploughing | | | |
| | Harrowing | | | |
| Planting | Seeds | | | |
| | Fertilizer | | | |
| | Transport | | | |
| | Planting labour | | | |
| Bird scaring | Labour | | | |
| 1st Weeding | labour | | | |
| Agrochemicals | Insecticide | | | |
| | Fungicide | | | |
| | Folia | | | |
| | Labour | | | |
| 2nd Weeding | Labour | | | |
| Bird scaring at flowering stage | | | | |
| Harvesting | Labour | | | |
| | Loading | | | |
| | Drying | | | |
| | Packaging bags | | | |

**D4.** Apart from sorghum farming, of the total land can you tell us what other activity is engaged in the plot(s) and the number of acres under each agrienterprises? What is the tenure of each parcel of land in the short season (Feb/June 2018)

| Plot/ parcel | Land use | Acres | Land tenure |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

**Land use**1= Sorghum acres under each agrienterprises [ ]; 2=finger millet farming (acres) [ ]; 3=maize growing (acres) [ ]; 4== Animal feed cultivation / Grazing [ ]; 5=Others specify [ ]

**Land tenure:** 1=owned with title deed 2=owned without title deed 3= Rented 4=owned by parents 5=Communal/ government/ cooperative

**D5.** How long have you been living in Tharaka Nithi County (in years).....

**D6.**Of the years you have been living in Tharaka, how long have you been doing sorghum farming (in years)? …….

**D7.**Do you own any livestock ……..*(1=Yes, No=2)*

**D8.**If yes tell me the type and number of livestock owned

| | Amimal | Number |
|---|---|---|
| 1. | …….. | …….. |
| 2. | …….. | …….. |
| 3. | …….. | …….. |
| 4. | …….. | …….. |
| 5. | …….. | …….. |
| 6. | …….. | …….. |

**D9.**Are there any cultures or belief that hinder you from adopting the improved varieties

**D10.** If **Yes** in **D7**, Kindly name them…….

**MARKETING**
**Sorghum Marketing and Market information**

**E1.** Do you sell sorghum surplus? …… Yes=1 No=2

| **E2.** Buyer | **E3**. Reason for choosing this buyer | **E4**. Distance to the buyer (Km) | **E5.** Time taken to establish with a buyer (Years) | **E6**. Price per Kgs (Kshs) | **E7**. Quantity sold per 3 Month (Kgs)/ quantity demanded | **E8**. Quantity sold per Year (Kgs)/ quantity demanded | **E9.** Amount of money received per month (Kshs) | **E10**.Amount of money received per Year (Kshs) | **E11**.Mode of payment | **E12.**Duration between quantity delivery and payment (days |
|---|---|---|---|---|---|---|---|---|---|---|
| Buyer1(please specify) | | | | | | | | | | |
| Buyer 2(please specify) | | | | | | | | | | |
| Buyer 3(please specify) | | | | | | | | | | |

*Codes*

| ***Buyer*** | ***Reason*** | ***Mode of payment*** | ***Duration of payment*** |
|---|---|---|---|
| *1. Individual/consumers/ neighbours* | 1. *Consistent and pays cash* | *1. Cash daily* | *1.Daily* |
| *2. Middlemen* | 2. *Quantity bought* | *2. Cash weekly* | *2.Weekly* |
| *3. Retailers* | 3. *Better prices* | *3. Cash monthly* | *3.Fortnightly* |
| *4. Trade groups* | 4. *Under contract* | *4. Bank* | *4.Monthly* |
| *5. Processors* | 5. *Near collection centre* | *5. SACCO* | *5.Other (specify* |
| | 6. *Other(specify)* | *6. Other(specify)* | |

| E13.Source of market information | E14.Source of information on prices |
|---|---|
| | |
| | |
| | |
| | |

*Codes*

| ***Information source*** | |
|---|---|
| *1. Cooperative* | *4. Neighbour* |
| *2. Newspaper* | *5. Other(specify)* |
| *3. Radio* | |

**INNOVATION USED IN THE FARM**

**F1.** Do you use any innovation on your farm? …… *(Yes=1 No=2)*

| **F2.** Innovations | **F3.** Reason for choosing this innovation | **F4.** Trainer | **F5**. Time taken to adopt This innovation | **F6**. Frequency of use | **F7**. Quantity harvested from these innovations |
|---|---|---|---|---|---|
| Innovation 1(please specify) | | | | | |
| Innovation 2(please specify) | | | | | |
| Innovation 3(please specify) | | | | | |
| Innovation 4(please specify) | | | | | |

***Codes***

| ***Innovation*** | ***Reason*** | ***Trainer*** | ***Period of adoption*** | ***frequency*** |
|---|---|---|---|---|
| *1. Improved varieties of seed* | *1. Easy to apply* | *1. Government extension staff* | *1. Days* | 1. *Often* |
| *2. GAP (use fertilizers, intercropping, conservation agriculture)* | *2. Supplied with necessities to use* | *2. Research institution* | *2. Weeks* | 2. *Once* |
| *3. Contract farming* | *3. Good yields* | *3. Friends/neighbours* | *3. Months* | 3. *Twice* |
| *4. Collective action* | *4. Availability of extension* | *4. NGOs* | *4. years* | 4. *Always* |
| *5. Financial support* | *5. Other(specify)* | *5. Other(specify)* | *5. Other (specify* | 5. *Never* |
| *6. Capacity* | | | | 6. *Other(specify)* |

*Building of farmers*

7. *Other(specif)*

**INNOVATIVE CAPACITIES OF AN AGRIENTERPRISES**

| | Description (scale of 1 to 5 1= strongly disagree, 2=Disagree, 3=Do not know, 4=Agree, 5=Strongly agree | Scale |
|---|---|---|
| Production innovativeness | **G1.** My agrienterprises ’s new products are often considered as very unique by customers | |
| | **G2.** My agrienterprises develop new product/service | |
| | **G3.** In comparison to the competition, my agrienterprises have introduced more innovations in the past 5 years | |
| | **G4**. My agrienterprises 's recent new product is significantly different from previous productions | |
| | **G5**. In comparison to the competition, my agrienterprises 's production is successful | |
| Process innovativeness | **G6**. My agrienterprises have flexible production methods which can be changed efficiently | |
| | **G7**. My agrienterprises has focused on smart business processes upstage | |
| | **G8**. My agrienterprises uses new delivery and distribution network | |
| | **G9**. My agrienterprises invest in new techniques/ equipment to improve its activities | |
| | **G10**.In the last 2 years, my agrienterprises 's production method is better | |
| Strategic innovativeness | **G11**.My agrienterprises have a good range of product grades to suit the customer choice | |
| | **G12.**In my agrienterprises, Key decision maker has abilities to simulate future market | |
| Market innovativeness | **G13**.New variety produce in my agrienterprises often take up against new competition | |

| | | |
|---|---|---|
| | **G14**.My agrienterprises marketing strategies are considered effective | |
| | **G15**.My agrienterprises involves its market partners when placing new product in the market | |
| | **G16**.My agrienterprises produce products that address customer needs | |
| | **G17**.My agrienterprises explores new market avenues | |
| Behavioural innovativeness | **G18.**In my agrienterprises, while employing, ability to innovate is critically evaluated | |
| | **G19.**My agrienterprises has structured process to approve new ideas for implementation | |
| | **G20.**Innovative behaviours are rewarded often | |

**GROUP PARTICIPATION**

**H1.** Do you belong to a farmer group/organization in the community? ……. *(Yes=1 No=2)*

| **H2.** Group | **H3.** What is the purpose/activities for the group | **H4.** Are there any requirements for joining the group *(1=Yes, No=2)* | **H5.** what are the requirements? | **H6**. What kind of relationship exists between the members of your group | **H7**. What position do you hold in the group | **H8.** Period of being the group |
|---|---|---|---|---|---|---|
| Group1(specify) | | | | | | |
| Group 2(specify) | | | | | | |
| Group3(specify) | | | | | | |
| Group4(specify) | | | | | | |

| ***Type of group*** | ***Requirements*** | ***Relationship*** | ***Position*** |
|---|---|---|---|
| *1. Saving and credit (Chama)* | *1. Pay membership fee* | *1. Relatives* | *1. Chairperson* |
| *2. Church group* | *2. Minimum farm size requirement* | *2. Neighbors* | *2. Vice chair* |
| *3. Farmers* | *3. Quality of the output* | *3. Friends* | *3. Secretary* |
| *4. Welfare* | ***4.*** *Declare your property* | *4. Farmers* | *4. Treasurer* |
| *5. Widows/Widowers* | ***5.*** *Be from the same village* | 5. *Others (specify)* | *5. Member* |
| *6. Family group* | | | *6. Others (specify)* |
| *7. Others (specify)* | ***6.*** *Others (specify)* | | |

**H9**. From a scale of 1-10, how do you rate your decision making in the groups?

**H10**. From a scale of 1-10, how do you rate your trust on members on the group?

**H11**. How did you get information about the farmer groups?

1=Fellow farmers [ ]; 2=Export agents [ ]; 3=Media advertisement [ ]; 4=Self-initiative [ ]

5=Friends [ ]; 6= Other (specify) ……

**H12**. If **NOT** a group member, give reasons

.....

.....

**H13.** Would you like to be a member? …… *(Yes=1 No=2)*

**H14**. If Yes, what stops you from jooining a group?

| Reason | *Tick* |
|---|---|
| 1. Lack of trust with members | |
| 2. Don't meet the quality standards | |
| 3. Don't meet the minimum quantity delivery | |
| 4. High membership fee | |
| 5. Lack of time to attend meetings | |
| 6. Distance with group members | |

**CREDIT ACCESS, EXTENSION AND TRAINING**

**I1**. Have you ever acquired any credit in the last year? …… *(Yes=1 No=2)*

**I2.** What was your reason for borrowing?

1=Buy production inputs [ ]; 2=Medical bills [ ]; 3=School fees [ ]; 4= Others (Specify)

**I3.** What was the source of the credit advanced and how much it was?

| | **Source** | ***Tick*** | **Amount (Ksh)** |
|---|---|---|---|
| 1. | Bank | | |
| 2. | SACCO | | |
| 3. | Microfinance | | |
| 4. | Friend/relatives | | |
| 5. | Groups | | |
| 6. | Other(Specify) | | |

**I4**. How did you spend the loan last year on the total borrowed from each source, specify uses and amounts herein %

1=Fees…….

2=Livestock….

3=Food……

4=Household items…..

5=Crops……..

**I5.** If **No** in no. **I1**, give reason (***please tick one that is most applicable***)

1. No collateral
2. Defaulted on previous loan
3. High interest rate
4. Not aware of credit facilities
5. Others (Specify)_____

**I6.** Have you ever attended any training or seminar on sorghum? *(Yes=1 No=2)*

**I7**. Did you pay for the training? …… *(1=Yes, No=2*

**I8**. If yes in 7.1, then how much?**.....**

**I9**. How long did the training take…….

**I10.** If yes, which topics were discussed?

1. Production of sorghum
2. Marketing of sorghum
3. Sorghum value addition techniques
4. Others_____

**I11.** How many times are you visited per month by extension officer? _____

**I12**. If yes,who provided the extension service or technical advice on sorghum production?

**1=**Fellow farmer [ ]; **2=** Government officers [ ]; **3=**NGOs [ ]; officers [ ]; **4=**Other sources (Specify)_____

**I13**. Have you been contracted by any organization…… *(1=Yes, No=2*

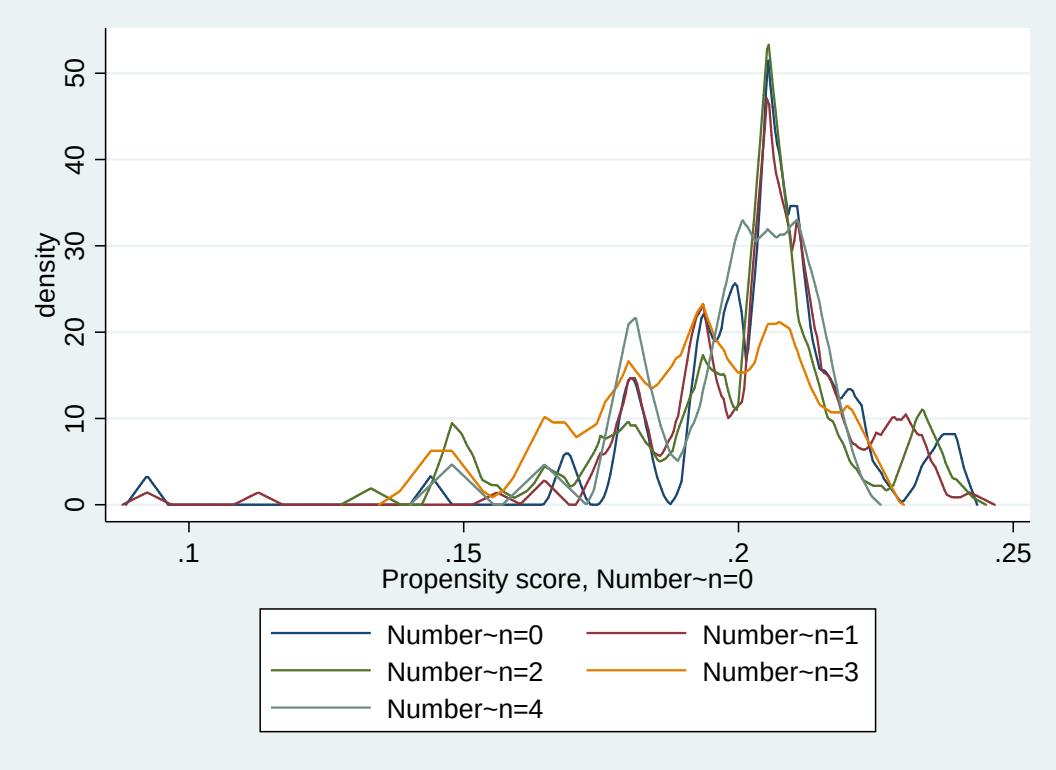
*Your participation in this study is greatly appreciated. Thank you for your time! Once again, I assure you that your identity will remain* ***STRICTLY CONFIDENTIAL.***

## Appendix 2 Negative Binomial model results

```
nbreg Numberofinnovation age Gender marital_status years_schooled householdsize
landtenureinLongseasonMa Sharesold Oftheyearsyouhavebeenlivin PriceperKgsKshs
DistancesKm Doyoualwaysreceivemarketinf Doyoubelongtoafarmergroup
Haveyoueveracquiredanycredi Haveyoubeencontractedbyany ProductInn ProcessInn
MarketInn

Negative binomial regression                    Number of obs     =        384
                                                LR chi2(15)       =     193.64
Dispersion     = mean                           Prob > chi2       =     0.0000
Log likelihood = -503.24548                     Pseudo R2         =     0.6905

------------------------------------------------------------------------------
         Numberofinnovation |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------------+-------------------------------------------------------------------
                        age |  -.0019406   .0034354    -0.21   0.538    -.0096338    .0077526
                     Gender |  -.9641857   .0882378    -1.05   0.273    -.3508582    .1064869
              years_schooled |   .0168785   .0083747     1.98   0.030     .0002124    .0377447
               householdsize |   .0330547   .0174984     1.75   0.059    -.0047255    .0850348
   landtenureinLongseasonMa |   .0223779   .1767979     0.13   0.899    -.3241396    .3688953
                  Sharesold |  -.0190293   .1578288    -0.17   0.903     -.346168    .2921093
      Yearsoffarmexperience |   -.011144    .004316    -2.20   0.005    -.0229552   -.0013329
             PriceperKgsKshs |  -.0052672   .0050927    -0.88   0.286    -.0170126    .0064782
                DistancesKm |   .0427827   .0243522     1.22   0.075    -.0255344    .1102998
Doyoualwaysreceivemarketinf |  -.2664274   .0770281    -2.39   0.000    -.4739225   -.0469322
  Doyoubelongtoafarmergroup |   .5880553   .0709205    -5.96   0.000     -.767916   -.3879945
Haveyoueveracquiredanycredi |  -.0410499   .0974442     0.24   0.672    -.2179081    .2785279
 Haveyoubeencontractedbyany |   .1971566    .109454    -1.36   0.071     -.514802    .0924889
                 ProductInn |   .1276992   .0741309     1.52   0.086    -.0353546     .278753
                 ProcessInn |   .1225755   .0603535     1.20   0.041    -.0637743    .2649253
                  MarketInn |   .0882049   .0642952    -0.94   0.169    .2533003    .0888906
                      _cons |  -.0871368   .3064291     2.84   0.004     .5180081    2.818728
----------------------------+-------------------------------------------------------------------
```

```
                    /lnalpha |  -20.51249          .                           .            .
-----------------------------+----------------------------------------------------------------
                       alpha |   1.23e-09          .                           .            .
------------------------------------------------------------------------------------------------

LR test of alpha=0: chibar2(01) = 0.00                  Prob >= chibar2 = 1.000
```

## Appendix 3: Estimated Probabilities of Assignment to Treatment Units




## Appendix 4: Regression Adjustment (RA); POM and ATET of treatment 0

```
teffects ra ( Totalquantyharvets age Gender years_schooled householdsize PriceperKgsKshs
DistancesKm Oftheyearsyouhavebeenlivin Doyoubelongtoafarmergroup_1
Haveyoueveracquiredanycredi_1 Haveyoubeencontractedbyany_1 ProductInn ProcessInn MarketInn ,
poisson) (Numberofinnovation),ate control(0)

Iteration 0:   EE criterion =  2.451e-15

Iteration 1:   EE criterion =  5.028e-25

Treatment-effects estimation                    Number of obs      =        384

Estimator      : regression adjustment
```

```
Outcome model  : Poisson

Treatment model: none

------------------------------------------------------------------------------------------------
                               |               Robust
          Totalquantyharvets |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------------
ATE                            |
           Numberofinnovation |
                     (1 vs 0) |   111.1663    113.428     0.98   0.327    -111.1485    333.481
                     (2 vs 0) |   391.2377   135.8424     2.88   0.004     124.9914    657.484
                     (3 vs 0) |   596.6966   150.3856     3.97   0.000     301.9461    891.447
                     (4 vs 0) |    524.857   320.9334     1.64   0.102    -104.1609   1153.875
-------------------------------+----------------------------------------------------------------
POmean                         |
           Numberofinnovation |
                             0 |   871.9515   88.75975     9.82   0.000     697.9855   1045.917
------------------------------------------------------------------------------------------------

.  nlcom (_b[ATE:r1vs0. Numberofinnovation]/_b[POmean:0.Numberofinnovation])

       _nl_1:  _b[ATE:r1vs0. Numberofinnovation]/_b[POmean:0.Numberofinnovation]

------------------------------------------------------------------------------
Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |   .1274914   .1403729     0.91   0.364    -.1476345    .4026173
------------------------------------------------------------------------------

.  nlcom (_b[ATE:r2vs0. Numberofinnovation]/_b[POmean:0.Numberofinnovation])

       _nl_1:  _b[ATE:r2vs0.Numberofinnovation]/_b[POmean:0.Numberofinnovation]

------------------------------------------------------------------------------
Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |   .4486921   .1885097     2.38   0.017     .0792198    .8181643
```

```
------------------------------------------------------------------------------

. nlcom (_b[ATE:r3vs0.Numberofinnovation]/_b[POmean:0.Numberofinnovation])

       _nl_1:  _b[ATE:r3vs0.Numberofinnovation]/_b[POmean:0.Numberofinnovation]

------------------------------------------------------------------------------

Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]

-------------+----------------------------------------------------------------

       _nl_1 |   .6843232   .2204468     3.10   0.002     .2522554    1.116391

------------------------------------------------------------------------------

. nlcom (_b[ATE:r4vs0.Numberofinnovation]/_b[POmean:0.Numberofinnovation])

       _nl_1:  _b[ATE:r4vs0.Numberofinnovation]/_b[POmean:0.Numberofinnovation]

------------------------------------------------------------------------------

Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]

-------------+----------------------------------------------------------------

       _nl_1 |   .6019338   .3872622     1.55   0.120    -.1570861    1.360954

------------------------------------------------------------------------------
```

## Appendix 5: Inverse Probability Weighting; POM and ATET of treatment 1

```
teffects ipw ( ln_gm)(Numberofinnovation age Gender years_schooled householdsize
PriceperKgsKshs DistancesKm Oftheyearsyouhavebeenlivin Doyoubelongtoafarmergroup_1
Haveyoueveracquiredanycredi_1 Haveyoubeencontractedbyany_1 ProductInn ProcessInn MarketInn),
control(1) pstolerance (1e-08)

Iteration 0:   EE criterion =  1.916e-16

Iteration 1:   EE criterion =  3.351e-28

Treatment-effects estimation                    Number of obs     =        384

Estimator      : inverse-probability weights

Outcome model  : weighted mean

Treatment model: (multinomial) logit

------------------------------------------------------------------------------------------
                             |               Robust
                      ln_gm |      Coef.   Std. Err.      z    P>|z|    [95% Conf. Interval]
-----------------------------+------------------------------------------------------------
ATE                          |
           Numberofinnovation |
                     (0 vs 1)  |  -.1125324   .1309515    -0.86   0.390    -.3691926   .1441279
                     (2 vs 1)  |   .1765824   .1089471     1.62   0.105    -.0369499   .3901147
                     (3 vs 1)  |   .9844636    .149937     6.57   0.000     .6905924   1.278335
                     (4 vs 1)  |   .8235915   .1033021     7.97   0.000     .6211232    1.02606
-----------------------------+------------------------------------------------------------
POmean                       |
           Numberofinnovation |   9.422268   .0751828   125.32   0.000     9.274913   9.569624
------------------------------------------------------------------------------------------

.  nlcom (_b[ATE:r2vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation])

       _nl_1:  _b[ATE:r2vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation]

------------------------------------------------------------------------------
       ln_gm |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |    .018741   .0116624     1.61   0.108    -.0041169    .0415988
```

```
------------------------------------------------------------------------------

.  nlcom (_b[ATE:r3vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation])

       _nl_1:  _b[ATE:r3vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation]

------------------------------------------------------------------------------

       ln_gm |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]

-------------+----------------------------------------------------------------

       _nl_1 |   .1044826   .0163352     6.40   0.000     .0724663     .136499

------------------------------------------------------------------------------

.  nlcom (_b[ATE:r4vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation])

       _nl_1:  _b[ATE:r4vs1.Numberofinnovation]/_b[POmean:1.Numberofinnovation]

------------------------------------------------------------------------------

       ln_gm |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]

-------------+----------------------------------------------------------------

       _nl_1 |   .0874091   .0114874     7.61   0.000     .0648941     .109924
```

## Appendix 6: Inverse Probability Weighting; POM and ATET of treatment 2

```
teffects ipwra ( Totalquantyharvets age Gender years_schooled householdsize
Howmanyacresisyourfarm landtenureShortseasonSept PriceperKgsKshs DistancesKm
Oftheyearsyouhavebeenlivin Doyoubelongtoafarmergroup_1 Haveyoueveracquiredanycredi_1
Haveyoubeencontractedbyany_1 ProductInn ProcessInn MarketInn , poisson) ( Numberofinnovation
PriceperKgsKshs DistancesKm),atet control(2)

Iteration 0:   EE criterion =  9.089e-19

Iteration 1:   EE criterion =  1.714e-25

Treatment-effects estimation                    Number of obs     =        384

Estimator      : IPW regression adjustment

Outcome model  : Poisson

Treatment model: (multinomial) logit

------------------------------------------------------------------------------------------------

                                |               Robust

           Totalquantyharvets |      Coef.   Std. Err.      z    P>|z|    [95% Conf. Interval]

-------------------------------+----------------------------------------------------------------

ATET                           |
```

```
           Numberofinnovation |
                    (0 vs 2)  |  -444.2937   174.0965    -2.55   0.011    -785.5165  -103.0709
                    (1 vs 2)  |   -461.846   173.4196    -2.66   0.008    -801.7421  -121.9499
                    (3 vs 2)  |   566.9992   658.9756     0.86   0.390    -724.5691   1858.568
                    (4 vs 2)  |  -44.69466   350.2684    -0.13   0.898    -731.2082   641.8189
-----------------------------+------------------------------------------------------------------
POmean                       |
           Numberofinnovation |
                           2  |    1280.45   160.2733     7.99   0.000     966.3196    1594.58
------------------------------------------------------------------------------------------------

 nlcom (_b[ATET:r3vs2.Numberofinnovation]/_b[POmean:2.Numberofinnovation]), noheader


------------------------------------------------------------------------------
Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |   .4428126   .5329739     0.83   0.406    -.6017971    1.487422
------------------------------------------------------------------------------

. nlcom (_b[ATET:r4vs2.Numberofinnovation]/_b[POmean:2.Numberofinnovation]), noheader

------------------------------------------------------------------------------
Totalquant~s |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _nl_1 |  -.0349054   .2716442    -0.13   0.898    -.5673184    .4975075
```

## Appendix 7: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **572373**

Date of Issue: **03/April/2020**

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**Appendix 8: Publication abstract**

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# Effects of Production and Market Innovations on the Level of Competitiveness of Sorghum Small Scale Agrienterprises

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## Abstract

Agricultural innovations are keys to economic growth, income stability as well as nutritional enhancement particularly in marginal areas since they are well adapted to poor or unpredictable agro-ecological conditions. Innovation is a critical player that is seen to bring competitiveness, increase productivity and efficiency to agrienterprises. Despite that, there is limited empirical evidence on whether the uptake of the innovations has on sorghum competitiveness in small scale farm level agripreneurs in most ASALs of Eastern Kenya. This study examines the effect of production and market innovation on the competitiveness of sorghum agripreneurs, using primary data collected in 2019 from a total of 384 randomly selected small scale agrienterprises. A multivalued treatment effect model was applied to determine the role of innovation on the competitiveness of sorghum enterprises. Farm productivity and gross margin analysis were used to measure the competitiveness of the agrientreprises. The results indicated that gross margin and farm productivity of sorghum agrienterprises increase with an increase in the number of innovations used. These innovations include the uses of improved sorghum seeds, conservation agriculture, and group marketing. But also, there was a decrease in both gross margin and productivity for the agrienterprises with the highest number of innovations in the farm at saturation level. The results implied that the kind and the number of innovations employed in agrienterprises development are critical in its profitability and productivity. Therefore, interventions targeting usage of innovations in sorghum agrienterprises should be sensitized to integrate different innovations on product, process, and market in enhancing competitiveness.

## Keywords

Product Innovation, Market Innovation, Competitiveness, Multivalued