

**INFLUENCE OF COLLECTIVE ACTION PARTICIPATION ON TECHNICAL  
EFFICIENCY AMONG SMALLHOLDER BANANA PRODUCERS IN KISII AND  
NYAMIRA COUNTIES, KENYA**

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**A Thesis Submitted to Graduate School in Partial Fulfilment of the Requirements for the  
Master of Science Degree in Agricultural Economics of Egerton University**


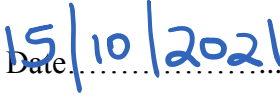
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**NOVEMBER, 2021**

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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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## **DEDICATION**

This thesis is dedicated to my family who have stood with me throughout my academic journey.

## **ACKNOWLEDGEMENTS**

I, first of all, give thanks to the Almighty God for guiding me through with good health in the course of my study at Egerton University. Secondly, I also thank the Department of Agricultural Economics and Agribusiness Management of Egerton University for offering me a chance to pursue the course, and the lecturers who took me through coursework both at undergraduate and post-graduate level. Their contributions have made it possible to go through the process with a good theoretical background. Thirdly, I thank my able supervisors, Dr. Tim. Njagi and Prof. H. K Bett for sacrificing their time and knowledge to offer me guidance in coming up with the thesis without demanding any compensation. Fourthly, I pass my gratitude to the data management team and director Tegemeo Institute of Agricultural Policy and Development for allowing me to use their data for my academic project. Without support, it could be difficult to complete the study. On the same, I want to thank the data collection team who endured to collect high quality and reliable data. Finally, I thank everyone who has contributed directly or indirectly towards my academic journey in terms of either monetary support, moral support, or any other support accorded in in-kind form. Your input kept me going and has made me reach thus far.

## ABSTRACT

Banana is among the highest consumed food crops in Kenya, both as a fruit and staple across all income categories. Technically efficient production of bananas, therefore, holds potential towards the realization of food security and improving the general livelihood of the smallholder producers. The thesis analysed the influence of collective action, defined as participation in producer groups, on technical efficiency among smallholder banana producers in Kisii and Nyamira Counties in Kenya. The study had two objectives; to characterise the determinants of group participation; and to determine the technical efficiency levels among the smallholder farmers. As the smallholder farmers try to achieve technical efficiency, they are beset by several production challenges such as information access, input access, among others. The study used the logit model to identify the determinants of group participation and the stochastic frontier approach to evaluate the technical efficiency levels as well as sources of technical inefficiency of banana producers disaggregated by group participation. The basis of the findings was on cross-sectional data with a sample size of 113 and 147 smallholder banana farmers in Kisii and Nyamira Counties respectively. The sample size was obtained through a multi-stage sampling technique. The results obtained from logit model in Kisii County, age and mobile phone ownership had a significant positive effect on group participation. In Nyamira, the household head, gender, informal occupation, mobile phone ownership and access to extension advice had a significant positive impact, while formal occupation and condition of the road had a significant adverse impact on group participation. The stochastic production frontier model estimates showed that group members were more technically efficient across the two counties. Field size, use of manure and inorganic fertilizer had a significant positive effect on productivity levels among both group and non-group members across the two counties. Inefficiency levels were significantly negatively affected by the age, gender and informal occupation and access to extension services. Formal occupation showed positive significant effect on inefficiency levels. The findings manifested that collective action helps farmers to address various production needs, thus making them more technically efficient. It can be concluded that a policy action that motivates group membership by smallholder farmers would be impactful towards achieving more productivity.

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## **LIST OF ABBREVIATIONS AND ACRONYMS**

AEZ	Agro-Ecological Zones
AHBFI	Africa Harvest Biotech Foundation International
DEA	Data Envelopment Analysis
DRA	Development Regimes for Africa
FARA	Forum for Agricultural Research in Africa
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KNBS	Kenya National Bureau of Statistics
MLE	Maximum Likelihood Estimation
MOA	Ministry of Agriculture
TAPRA	Tegemeo Agricultural Policy Research Analysis
TC	Tissue Culture
USAID	United States Agency for International Development

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background Information**

Banana (*Musa spp.*) is an important food crop valued as world's fourth valuable crop with high nutritional and health benefits (Singh et al., 2016). Banana provides between 81Kcal/100grams and 97Kcal/100grams depending on the form in which it is consumed. The crop also provides 20.1g of carbohydrates and 3.6g of fibre (Food Agriculture Organization [FAO], 2018). The lower calories composition of green banana compared to other staple foods such as maize, sorghum and wheat make it a healthier source of energy and vitamins. Besides, it is a rich source of vitamins A, B6, C and D, and essential minerals such as potassium which is vital in maintaining normal blood pressure and heart function (FAO, 2018). Moreover, it is rich in magnesium which helps in the soothing and protection against ulcers and a remedy for constipation among children (Singh et al., 2016). Due to the health and nutritional benefits, banana's per capita consumption has been increasing across entire Sub-Saharan Africa (Outlook, 2020).

In Kenya, ripe banana is one of the highest consumed fruits among the urban residents, while the plantains are ranked second across all income groups (FAO, 2020). The increasing demand for bananas in Kenya as a staple food can be attributed to changing climatic conditions which have become unfavourable for maize production as the main staple food and growing number of the population becoming more mindful of healthy diets due to increasing cases of nutrition-related non-communicable disease incidences (World Bank, 2020). In a study that was conducted among smallholder farmers in central Uganda on the determinants of food security, a unit increase in acreage of banana production area was found to have a corresponding 44% improvement of a household food security levels (Apanovich & Mazur, 2018). Apart from its contribution to food security, the crop is also a source of income at both macro and micro levels of the economy with high profitability potential (Muigai et al., 2021).

Considering the benefits of banana, increasing its productivity levels would be important in contributing to a healthy and food secure society, and impact positively on rural development (Muigai et al., 2021; World Bank, 2020). In order to increase productivity levels of bananas there

has been considerable amounts of investments on various interventions to come up with better varieties that are tolerant to the prevailing weather conditions, are disease-resistant and are also high yielding over the past one and a half decades (Karienyee et al., 2020). For instance, the Kenya Agricultural and Livestock Research Organization (KALRO) has continuously come up with new agronomic practices and improved banana varieties due to continuous changing climatic conditions. Such varieties include: Williams, Grand Nain, Giant and Dwarf Cavendish, Chinese Cavendish. The above varieties are more disease resistant, high yielding and mature faster than the traditional types (Kabuga, 2013; Muthee et al., 2019). Despite of the numerous interventions to increase the production levels of bananas, the production levels still remain below optimum (Faria, 2020).

The statistics from recent studies on production trends between 2008 and 2018 show that the total physical production stood at approximately 1.41 million tonnes annually in 2018 compared to 1.687 million tonnes in 2008 under a total area of around 100,000 ha of the cultivated land in Kenya. The production data translates to average yield of 14.1 tonnes/ha/year of bananas against a potential yield of 40 tonnes/ha/year (Faria, 2020). This level of productivity is quite low and unable to satisfy the increasing demand. The low productivity could be attributed to the high costs of inputs and implementation of various innovations considering the fact that the crop is predominantly produced by smallholder farmers. Moreover, smallholder farmers still predominantly dependent on rainfall which cannot provide a more reliable water supply for the improved varieties (Wahome et al., 2021).

The high yielding varieties of banana also require more fertilizers, intensive labour and specific skills for them to achieve better yields (Muthee et al., 2019). The associated additional costs lockout the majority of smallholder farmers from adopting the new technologies. Also, the smallholder farmers suffer from credit constraints, low asset endowment and lack of proper market infrastructure (Mwangi & Kariuki, 2015). Information asymmetry has made it difficult for the smallholder banana producers to access production-related information on research findings. For example, the majority of the farmers are unable to access extension services on the right types and quantity of fertilizers to apply during production, then right soil management

practices, as well as the better banana propagation practices (Muigai et al., 2021; Muthee et al., 2019).

Apart from information asymmetry, the smallholders are faced with limited access to better market for inputs and lack of access to better extension services. The highlighted challenges that face the smallholder farmers inform a serious need to increase farmer access and capacity building towards new innovations and production technology if technical efficiency is to be improved. Moreover, increasing the ability of smallholder farmers to access the suitable inputs and the credit facility, would be handy in enhancing their productivity (Kabuga, 2013).

In Kisii and Nyamira counties, banana production is a major cash crop alongside tea (Ministry of Agriculture [MOA], 2017). Over 75% of smallholder farmers in the two counties produce an average of 20 bunches of banana annually at an average weight of 25-35Kg/bunch. The produce translates to a range of 0.5 to 1 ton of bananas per household per year (Wahome, et al., 2021). Banana production earns the two counties an average of Kes1.025 billion annually. At the farm level, a farmer can earn Kes150, 000 per hectare per year on average from sales of fresh banana (FAO, 2020). Like other smallholder farmers, majority of the farmers in this area are faced with challenges of limited resource endowment.

Land in these counties is highly fragmented such that most of the farmers access land size ranging from 0.2 to 2.1 acres. Three quarters of the population in the areas own an average of 0.5 acres of arable land (Wahome et al., 2021). The small land size is largely attributed to the high population density that has put much pressure on agricultural land (Kenya National Bureau of Statistics [KNBS], 2017). The farmers are also faced with budgetary constraints which limit them from affording important agricultural inputs to enhance productivity (Songoro, 2020). Recognizing the problems of limited resources available to the smallholder farmers, increasing productivity would be more viable if the farmers become more technically efficient. It is therefore important to design proper ways to increase productivity under the aforementioned challenges. One of the ways of doing this would be to ensure that farmers are efficient in using the production resources available to them so as to realize maximum potential.

There are different mechanisms which have been employed by different development agencies to address the challenges facing smallholder banana producers; one of such mechanisms is participation in collective action. Collective action participation is believed to enhance farmer coordination and links them to market for inputs; reduce information asymmetry; and better manage transactions thereby reducing associated costs (Mukindia, 2014; Ombogoh et al., 2018). It is also believed to strengthen their bargaining power; enhance access to credit and innovations. Farmers who participate in collective action through group membership are believed to have better access to new technologies, inputs, credit, extension services and other production-related factors (Mutonyi, 2019). For example, in Kisii and Nyamira Counties, Africa Harvest Biotech Foundation International (AHBFI) has been working with smallholder banana producers since the year 2003.

In both of the counties, AHBFI worked with existing farmer groups which were identified with the help of the relevant ministry as well as other stakeholders. The main aim of AHBFI was to enhance farmer technical capacity so as to increase productivity and income from the banana enterprise. By the year 2014, approximately 5,022 farmers had been trained from the 401 farmer groups in Kisii and Nyamira counties. The organization also helped to link the producers to extension service providers, increase their access to Tissue Culture (TC) seed types through greenhouse technology and nursery establishment (Kabunga, 2012). Traditionally, the farmers have been relying on suckers from old plantations for propagation of bananas. The traditional method of propagation promotes diseases and pests spread.

The organization (AHBFI) came up with high yielding and pathogen-free plantlets, however the improved plantlets are expensive for most of the farmers. To ensure most farmers access and afford the plantlets, AHBFI provide limited subsidies on cost of planting materials; the organization also facilitates farmer group contacts and linkages with TC laboratories and local nurseries to help reduce transaction costs (Kabunga, 2012). Apart from AHBFI, other United States Agency for International Development (USAID) funded organizations such as the Kenya Agricultural Value Chain Enterprises (KAVES) also work with smallholder banana producers in groups in the region to increase their capacity as well as link them to production inputs. Even though farmers are being encouraged to join farmer groups so as to access a number of benefits

from interventions by such organizations; there are those farmers who still do not want to join such groups. It was important to know whether the category of farmers who joined the producer groups are in any way better than the non-members or not; and to know whether the group participants do have access to more benefits compared to the non-group participants. The study was necessary to investigate the effect of group participation on the technical efficiency levels of banana production.

## **1.2 Statement of the Problem**

While banana is one of the most important food and commercial crops in Kenya, its production at individual level by a smallholder farmer is often beset by a number of challenges. One of the significant hindrances to banana production has been inefficiency in utilization of production resources. One approach being used to address the challenges is through participation in collective action by smallholder farmers. Although the collective action mechanism has been gradually growing among smallholder producers, its effect on technical efficiency had not been estimated. The study was to provide information on the uncertainty that surrounds the effect of collective action through group participation on the technical efficiency levels with respect to smallholder banana producers in Kisii and Nyamira Counties of Kenya.

## **1.3 Objectives of the Study**

The study was directed by the general objectives and specific objectives which were divided in subsections.

### **1.3.1 General Objective**

To contribute to the existing knowledge on the role of collective action on improving agricultural productivity by evaluating its influence on farmer technical efficiency levels in banana production.

### **1.3.2 Specific Objectives**

- i. To characterise the determinants of collective action participation by smallholder banana farmers in Kisii and Nyamira Counties.

- ii. To determine the level of Technical Efficiency between group participants and non-participant banana producers in Kisii and Nyamira Counties.

#### **1.4 Research Questions**

- i. What are the factors that influence group participation by smallholder banana farmers in Kisii and Nyamira Counties?
- ii. Which is the level of technical efficiency of group and non-group member smallholder banana farmers in Kisii and Nyamira Counties?
- iii. What are the sources of technical inefficiency among group and non-group member smallholder banana farmers in Kisii and Nyamira Counties?

#### **1.5 Justification of the study**

Banana is one of the main commercial and food crops in Kenya, consumed as a dessert when ripe and staple food when green. It is majorly produced in the rural areas by small-holder farmers faced with numerous production challenges. Improving production efficiency among these smallholder farmers provides an impetus towards the realization of the economic growth of the rural areas. Bringing farmers together into groups has been one of the strategies commonly employed by various development agencies to help farmers cope with production challenges. The study was therefore important in trying to assess and understand how such institutions are performing in terms of fostering economic growth and development. Furthermore, in the current constitutional dispensation, agriculture is a devolved function to the county governments. The recommendations from this study would be very important for the county governments of Kisii and Nyamira in improving banana productivity through efficient use of production resources. The various development agencies and stakeholders including Community-Based Organizations (CBOs), and NGOs will use the findings of the study to evaluate their respective objectives.

#### **1.6 Scope and limitations of the study**

The study was based on data that was collected from Kisii and Nyamira Counties during a household survey conducted in the year 2014. The study specifically focused on technical efficiency of smallholder banana producers based on group participation by each of the two counties, and no comparison of the study results was made between the counties. One of the

limitations is that the data which was used for the study has no information about specific varieties of banana and their production levels. Secondly, lack of data on the amount of labour employed in banana production. Finally, the findings obtained from the study cannot be generalised to all crop enterprises due to differences in production requirements and process.

### **1.7 Definition of Terms**

The following terms were operationally defined in the study as explained in this section.

**Collective action:** This refers to the participation in a group by a given number of individuals pursuing a common good, with a major aim of improving each participant's socioeconomic welfare

**Smallholder farmer:** This refers to a farmer who has access to a maximum of 2.5 acres of arable land.

**Technical efficiency:** This is the effectiveness with which a farmer can use a given quantity of inputs accessible to them so as to maximize output.

**Productivity:** This refers to the total amount of harvest that can be achieved from a unit of set of agricultural inputs.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter focuses on the trend of banana production and collective action attributes in relation to agricultural production as per the empirical findings of the past studies. The chapter also provides a theoretical framework on collective action and production and a conceptual framework.

#### 2.2 Banana production in Africa

In Africa, bananas are mainly produced in Eastern and West Africa regions. West Africa produces 32% of worldwide plantain total production of bananas. Eastern Africa is the highest producer of highland bananas in Africa and the region contributes 20% to the worldwide banana output (FAO, 2020). There are four main types of bananas grown in Eastern African region, these are the cooking type (green bananas). There are the beer banana types that are mainly produced in Burundi and Rwanda, and finally the dessert and juice types (Njuguna et al., 2012).

Banana production in Kenya is mainly practised in the Central, Eastern and Western regions. The crop requires an altitude range of 0 to 1800 metres above sea level. The Western region contributes to about 65% of annual output, Central and Eastern region contributes approximately 27% with coast and Rift Valley region producing below 10% of the produce (Faria, 2020). The crop is produced in regions of altitude between 0 to 1800 metres above sea level. In Kenya banana occupies approximately 2% of total arable land which translates to about 100,000 ha. The crop annual total physical product is estimated at 1.4 million tonnes which contributes to 50% of the total domestic horticultural production in Kenya (MOA, 2017).

In the Kisii and Nyamira, the commonly produced types are the green banana that are commonly used as staple food, while the desserts are commonly grown in the eastern and central Kenya such as Meru, Embu and Kirinyaga among others (Wahome et al., 2021). The cooking (green) banana varieties include: the Uganda green, *Kiganda*, *nusung'ombe*, *mutahato*, *Grand naine*, *vallery*, *peripeta*, *lacatan* and *GradiShisikame*. The dessert varieties are: Uganda red, apple banana (*sukarindizi*), Chinese Cavendish, dwarf Cavendish, giant Cavendish, *short Kampala*, *bogoya* and *Gros Michel*. However, some of the varieties are used both as cooking and desserts

that include *Muraru*, *Bokoboko*, *Mkono watembo*, *Ng’ombe* and *gold finder*. In term of production levels, the average annual production of banana in Kisii County and Nyamira County according to horticultural department was approximately 4000 in each county metric tonnes in 2018 (Faria, 2020).

**Table 2.1: Summary of Banana Varieties in Eastern Africa**

<b>Green (cooked) type</b>	<b>Ripe (dessert) type</b>	<b>Dual purpose</b>
Uganda green	Apple banana ( <i>Sukarindizi</i> )	<i>Ngombe</i>
<i>Kiganda</i>	Chinese Cavedish	<i>Muraru</i>
<i>Nusung’ombe</i>	Dwarf Cavedish	<i>Bokoboko</i>
<i>Grand naine</i>	Giant Cavedish	MKono watembo
<i>Mutahato</i>	<i>Short Kampala</i>	<i>Bokoboko</i>
<i>Gradishikamane</i>	<i>Bogoya</i>	<i>Gold finger</i>
Vallery	<i>Gros Michel</i>	
<i>Peripeta</i>	<i>Uganda red</i>	
<i>Lacatan</i>		

*Note.* Adapted from Ministry of Agriculture (2017).

The past decade has witnessed an upward trend about the area under banana production in Kenya. However, there is no proper correlation between this trend and the resultant yields. Despite the increase in acreage under banana production, output has remained very low and stagnated within a range of 4-15 tonnes/ha against a potential of 30-40 tonnes/ha (Faria, 2020; Fischer & Qaim, 2014; Mungai, 2015).

### **2.3 Conceptualization of collective action**

Collective action can be defined as those actions that are taken by a group of people in pursuit of a common good or service that may otherwise not economical to be pursued individually. Collective actions are typically framed to resulting in some shared results, outcome, or public good which are non-excludable for relevant entities regardless of the contributions they have towards its realization (Coleman, 2017; Pretty, 2003). The concept is about the action taken by a group of people directly, or on its behalf through a given organization to pursue common interests (Gram et al., 2019). Gram et al. (2019) observed common features in the definition

which include: group of people; common and shared interest; and voluntary action to pursue the interests. Empirical studies which have been conducted to look into the collective action and its role in agriculture reveals that, the type of organization which supports such actions is very important in determining the outcome of a collective action (Gomez-Lavin & Rachar, 2021). Specifically, in the field of agriculture, it would be necessary to distinguish whether collective action is developed by an organization which is under direct control of farmers or controlled by external force like the government or non-governmental organization. From the perspective, two types of collective action are derived which are: (1) a cooperation which is a bottom-up, or farmer-to-farmer led collective action and (2) a coordination which is a top-down, agency led collective action (Pretty, 2003). The categorization implies different levels of government involvement whereby in most cases the farmer-to-farmer categories do not receive much government support while the other category is in most cases guided by government policy.

Available literature shows that the performance of collective action can be analysed in relation to natural resources and more significantly to public good and collective good where some scholars have identified certain factors to consider. The factors fall under four categories which include: resource system characteristics; group characteristics; Institutional arrangements; and the external environment (Ostrom, 1990; Pretty, 2003). The natural resource factors are related to the type of good involved, knowledge and predictability of such resources since information availability on issues such as technical requirements are crucial for implementing a collective action to enhance sustainability (Bodin, 2017).

The second category which is the group characteristics, are those that should enhance social relationships among the participants to promote the concept of social capital. The factors include trust, norms, reciprocity, obligations and expectations, values and attitudes, culture, information and knowledge, institutions, rules and sanctions (Bodin, 2017). Moreover, the success of collective action also depends on the institutional arrangements which include simple rules and effective monitoring and sanction systems, and the “thickness” of local institutions. The concept, thickness of local institutions is linked to a combination of social capital, human capital and political capital (Mantino, 2010). In the study, it was assumed that those who participate in collective action enjoyed those attributes that influence the performance of a collective action

though participation in farmers' producer groups. Consequently, the study determined how members of collective action benefited in terms of technical efficiency relative to others with respect to smallholder banana production.

#### **2.4 Determinants of collective action participation by smallholder farmers**

There are a number of studies that have been carried out to determine the impact of various socio-economic factors on collective action participation by smallholder farmers. For instance, in one of such studies that was to determine the factors that influence household decisions to participate in community-based organizations, education, land size, access to extension services were found to be a significant factors that positively influence probability of collective action participation (Ngango & Kim, 2019). In another similar study that was to evaluate the role of collective action participation on income among smallholder farming households in Malawi, Mango et al. (2017) found that, access to information, age and education level were key positive influencers of collective action participation.

In a similar study to determine the factors that influence group participation among smallholder farmers, households where the female had a role in decision making were more likely to join a farmer group (Musyoki et al., 2012). In another study, Tesfaw (2021) in a study to evaluate the determinants and impacts of farmer participation in collective action found that farmer's level of experience in farming activities, their education level, and credit access had a positive and significant effect group participation. In the latter study, the age of the farmer the size of landholding and the distance to the input market also had a significant and a positive impact on the probability of group membership. Similar findings were established in a study to determine the technical efficiency of smallholder rice farmers in Uganda (Melati et al., 2020).

In addition to the above, a study to investigate the determinants of group participation using the Logit model in Mbozi District of Tanzania, established that the marital status of the farmer, distance to the venue of the group meeting, as well as the age of the farmer had a significant impact on group membership (Lwezaura & Ngaruko, 2013). The study showed a positive correlation between age and group participation. In more other similar studies, farmers who are married and have higher level of education showed positive correlation with group participation

as a form of collective action. Consistent results were also reported for the farmers who had more access to information and those who had higher levels of income (Angon et al., 2021). The results from the study by Angon et al. (2021), however, showed that as the distance to the source of information increases, the chances of group participation by a smallholder farmer also increases (Angon et al., 2021; Lwezaura & Ngaruko, 2013).

The available literature was not sufficient to be relied upon in decision making. Moreover, there were a number of contradictions in the findings which calls for further research in the area to give more consistent information. The studies had also failed to exhaust the economic and physical factors which affect farmer decision-making process. This study incorporated more exogenous and endogenous household factors to give an in-depth understanding of the factors affecting group participation.

## **2.5 Factors affecting technical efficiency**

The section provided literature on those socio-economic attributes which had an influence on producers' technical efficiency. A number of literature had been written on how different socioeconomic factors affect the level of technical efficiency of farmers, however very little and sometimes contradicting information is available with regards to the role of collective action which is realized specifically through group participation. The most commonly used methodology by majority of the researchers in the determination of the level of technical efficiency is the Stochastic Frontier Approach (SFA) and the non-parametric Data Envelopment Analysis (DEA). For instance, Alwarritzi et al. (2016) used the SFA in estimating the technical efficiency levels of oil palm production in Indonesia. In the study, Alwarritzi et al. (2016) found that the gender of the farmer had a significant effect on technical efficiency - the male farmers were less technically inefficient than their female counterparts.

Similarly a study by Ayinde et al. (2015) to estimate the technical efficiency of maize farmers in Ogun state of Nigeria revealed a number of socio-economic factors that influence technical efficiency. Results from the maximum likelihood estimation model showed that, the household size of the farmer and the educational levels were statistically significant determinants of the technical inefficiency of the maize farmers (Ayinde et al., 2015). The study established that

increase in household size reduced inefficiency of production, a finding that could be attributed to the labour availability. However, higher education levels increased inefficiency, a finding that contradicts other previous findings from other studies such as study conducted by Maganga (2021). In a study by Nsimbila (2021) to determine cotton farmers' level of technical efficiency in Tanzania, education level, land consolidation, and access to credit services were found to negatively influence the technical inefficiency levels in cotton production systems.

Nsimbila (2021) further found age of the farmer to be a significant determinant of technical efficiency levels. The younger farmers below 25 years of age were more technically inefficient than their older colleagues. In another study to determine the productivity and the technical efficiency of pistachio producers, farmer experience, education level and social capital were found to have significant impact on the technical efficiency (Kurkinejad, 2021). In the study, Kurkinejad. (2021) found that the technical efficiency of farmers depend on social capital due to the support received in such arrangements. Farmers who received support in terms of labour supply, financial aid and information transfer were less inefficient than their counterparts who did not access such kinds of support

Endelaw et al. (2021) in a study conducted among the Teff producers in Ethiopia also revealed that the farmers who had received more extension visits and those who received higher amount of credit were more likely to be less technically inefficient in their production process. In another similar study to determine the level of technical efficiency and its determinants among smallholder rice producers in the Northern Ghana, Anang et al. (2018) found that the farmers who participated in collective action through group membership were more technically efficient than their counterparts who had no group memberships. From the same study, age, education level, gender and marital status were found to have significant effect on the technical efficiency levels of the farmers.

There were studies which had tried to evaluate the effect of self-help groups as a way of collective action among smallholder farmers in fostering increased production through creating farmer awareness, technology adoption, and accessibility to credit, access to inputs market. For instance, Mwaura et al. (2014), while studying the effect of farmer group on crop productivity

and technology adoption in Uganda, used Propensity Score Matching (PSM) to estimate the difference in the levels of performance between the group members and non-members. Their results revealed that collective action participation had a significant effect on maize and banana yield compared to non-group members. The results further showed that the group members were more technically efficient in maize production. The non-group members were also found to be more technically efficient in producing sweet potatoes (Mwaura et al., 2014). The results further showed that the members of a group do not necessarily have relative advantage in accessing all production resources and crop management technologies which could lead to inefficiencies in their practices (Anang, et al., 2018; Mwaura et al., 2014).

A study by Davies et al. (2012) revealed mixed performance by group members in Kenya, Uganda and Tanzania. In Kenya and Tanzania group members had shown significantly higher technical efficiency while in Uganda the crop yields by group members were not significantly higher than the yields by non-members. The findings from the study further revealed that there was higher use of planting fertilizers among the group members compared to non-group members in bean production at 5% significant level.

In another study which was conducted by Waluse (2012) to come up with the determinants of common bean productivity and production efficiency among smallholder farmers in Eastern Uganda found that the technical efficiency score of the common bean farmers in the study area was 48.20% using the stochastic frontier model for estimation. The results further revealed that farmers who participated in collective action showed a higher mean of efficiency level (48.71%) compared to non-participants which were lower than the overall level (47.54%). The results from the study showed no significant difference from t-test results (Waluse, 2012).

From the above literature on the factors affecting technical efficiency, it was evident that the findings gave mixed results on how group participation impacts on the technical efficiency levels of the group members. The available literature on the role of collective action on technical efficiency also gave a number of mixed results. Apart from contradictory information, much literature available only showed how collective action affected yields and accessibility to production factors, but did not show whether the farmers were more technically efficient than the

other counterparts. The study did not only provide more information on the influence of group participation on technical efficiency, but also did not find out how various factors within the group such as position held and type of services offered among others affect their efficiency levels. Such mixed findings informed the need for further research in the area to determine the roles such institutional arrangements play on technical efficiency levels of the smallholder farmer. The concept of technical efficiency is very important as it enables one to understand whether or not a smallholder farmer is able to use the scarce resources at their disposal to optimize their productivity.

## **2.6 Theoretical framework**

The theoretical framework gives discusses the production theory with a detailed focus on the technical efficiency. The section also describes the approaches used in estimating technical efficiency levels of smallholder farmers.

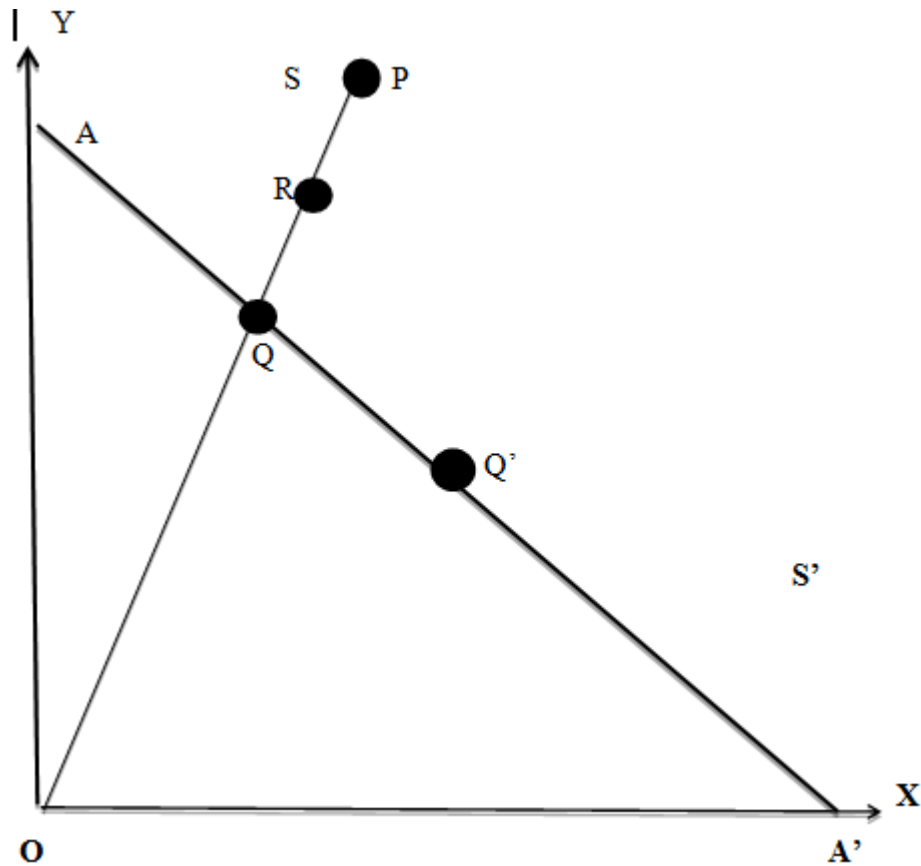
### **2.6.1 Theory of production**

The theoretical formulation of the proposed study will be based on the theory of production of a firm. The efficiency of a firm is defined as its actual productivity relative to maximal potential productivity (Farrell, 1957). Productivity is a term used to measure the value of performance of a firm. In agriculture, productivity can be defined as a measure of the value of output for a given level of inputs (Forum for Agricultural Research in Africa [FARA], 2006). The maximal potential productivity is defined by a production frontier while efficiency measurements involve the measurement of distances from observed data points to the frontier (Mohammad, 2009). The theory of a firm states that firms exist and make various decisions for the objective of maximising profits. To estimate the technical efficiency of a firm, it is important to understand how a producer makes decision. A producer is said to be economically efficient if the producer is operating on a production frontier. The literature suggests several alternative approaches to measure production efficiency, technical, price and cost approaches. The concluded study used the technical efficiency approach.

Measurement of technical efficiency is typically done by either parametric or non-parametric techniques. Parametric methods include production, cost, profit and revenue functions as

alternative methods of describing the production technology and determination of efficiency levels which specifically involves the estimation of the stochastic frontier (Anang et al., 2018). The Stochastic Frontier Approach (SFA) allows the estimation of maximum attainable output for a given set of inputs. It also allows incorporation of other factors beyond input and prices in the model, thus reveals all factors that influence the producer's ability to become efficient (Bauman et al., 2019). The parametric approach explicitly recognizes that production function represents a technically maximum feasible output level for a given level of farm inputs.

In a non-parametric model, for example, DEA, the structure of the model is not specified *apriori* but is determined from the available data. The strengths of non-parametric technique are that it does not require assumptions on the distribution of the error terms of the frontier production function. As a result, it does not impose a specific structure on the technology. The DEA technique allows the use of disaggregated data and it does not suffer from problems of heteroscedasticity and multicollinearity. However, the shortcomings of the non-parametric approach are that the statistical tests cannot be determined, and the approach only provides an upper bound to the true efficiency estimates in that any deviations from the production frontier are attributed to inefficiency (Shafiq et al., 1999). Moreover, non-parametric method is also highly susceptible to outliers and inconsistencies in the data. In the study, a trans-log function of SFA was used to determine the scores of technical efficiency as well as factors that affect technical inefficiency of a banana farmer. Figure 2.1 shows how a banana farmer can combine a given set of inputs LAND (Y) and LABOUR (X) to produce.



**Figure 2.1: Technical, Allocative and Economic Efficiency**

*Note.* Adapted from Anang et al. (2018).

From Figure 2.1, the producer is said to be technically efficient when he produces along the Isoquant  $SS'$ , or efficiency frontier. This shows the Least Cost Combination (LCC) of inputs to produce the same level of output  $Q$ . At point  $P$  the farmer is not technically efficient because he can still produce using fewer inputs at  $Q$  or any point along  $SS'$ . The technical efficiency of the farmer is given by  $OQ/OP$ . Technical Efficiency is 1 for fully efficient firms, below this the farmer is said to be technically inefficient.

The Isocost line  $AA'$  shows the different combinations of input  $X$  and  $Y$  in terms of price ratio which the farmer can afford as per his budget. When the same firm produces at  $P$  it would be allocative inefficient compared to that producing at point  $R$ . The farm's level of Allocative Efficiency is given by  $OR/OQ$ . The product of Technical and Allocative Efficiency give

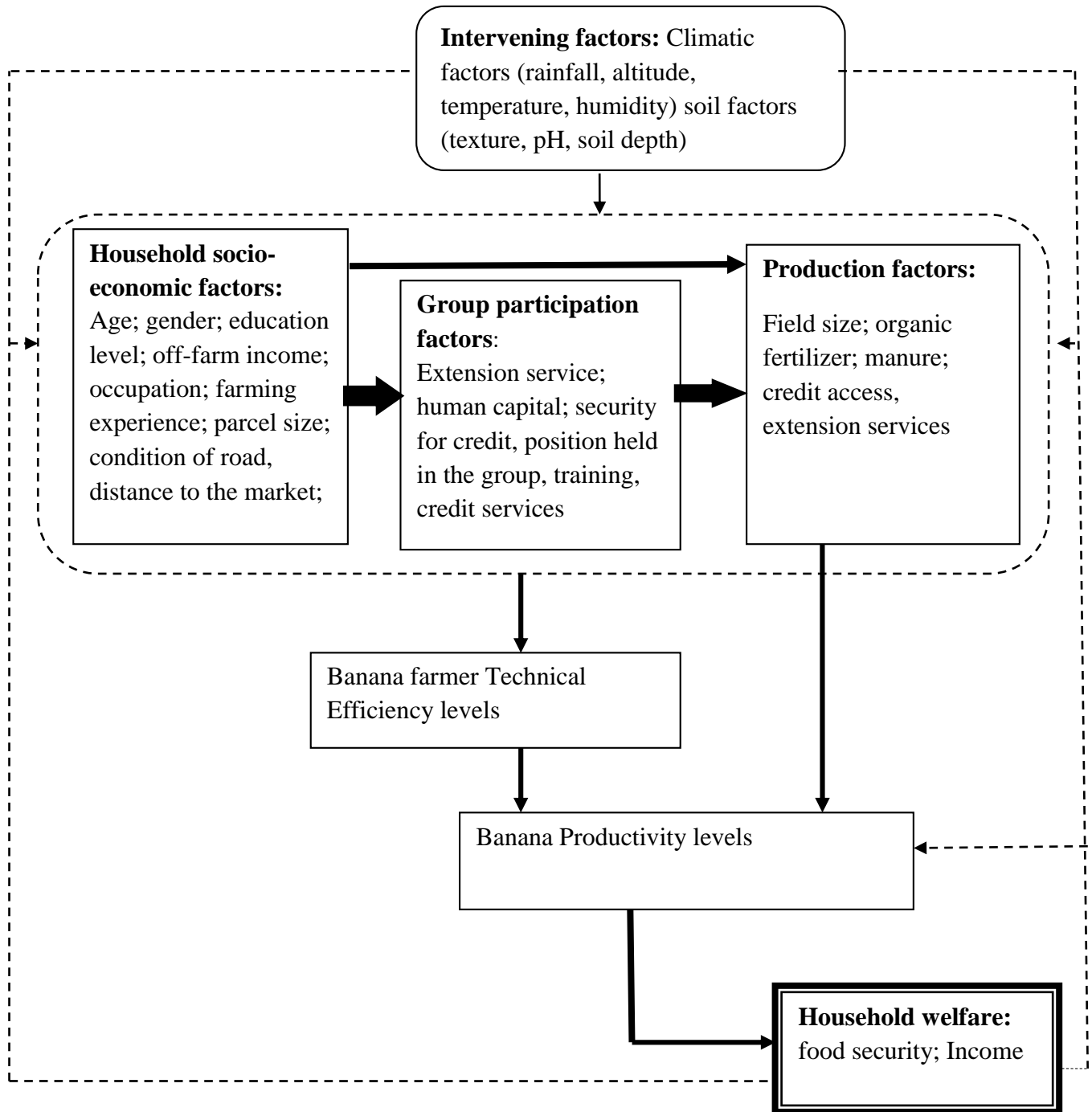
Economic Efficiency level which is OR/OP. It follows the theoretical cost minimisation due to the shift of inputs combination from P to R. In such a case a producer who is producing at P could become more efficient at point Q'. For the purpose of the study, focus was only made on technical efficiency of a smallholder farmer.

## **2.7 Conceptual framework for producer decision making process**

The study was conceptualized under the framework of the New Institutional Economics (NIE) based on the Institutional Analysis and Development approach (IAD). It was assumed that individual banana farmer would rationally decide to participate in a collective action when the benefits were expected to be higher hence maximizing household's socio-economic welfare. A rational banana producer, therefore, joins a group when expected level of satisfaction in terms of utility is higher, that is  $U_c > U_i$ , where  $U_c$  is the utility due to participation and  $U_i$  due to non-participation. The expectation was that, the higher the expected benefits by the household the higher the probability of the smallholder banana producers in Kisii and Nyamira Counties joining producer groups in order to enjoy associated benefits.

In the concept, it was assumed that the participation of an individual farmer in a group would be influenced by a vector X of independent socio-economic factors with associated unknown parameters. When the producing household participated in such collective action, it gained associated benefits that include, human capital, better access to market information, better market linkages, better access to credit facility, better access to extension services, and access to better technological information. It was assumed that the group factors on one hand directly influence how technically efficient a banana farmer would become due to increased awareness and skills for adoption of new technology, and effective use of available inputs to achieve maximum output. On the other hand, the group factors were assumed to have impact on accessing production factors which together with technical efficiency would influence the level of banana productivity levels of a household, thus influencing the household welfare in terms of household food security and income. Consequently, a smallholder farmer, depending on the socio-economic characteristics and expected benefits, would decide either to join a producer group or not. The farmer's decision in one way or another would have a direct impact on the level of technical efficiency, which would, in turn, affect the banana productivity levels and

eventually household welfare. As the welfare changes, it influences changes in the household factors which would inform the decision-making process as to joining or not joining farmer group. The entire process is affected by intervening variables such as climatic factors, soil factors and NGO policies which in one way or another influence the production decisions.



**Figure 2.2: A Conceptual Framework for a Banana Producer Decision-making Process**

*Note.* Adapted from Marshall (1998).

## **CHAPTER THREE**

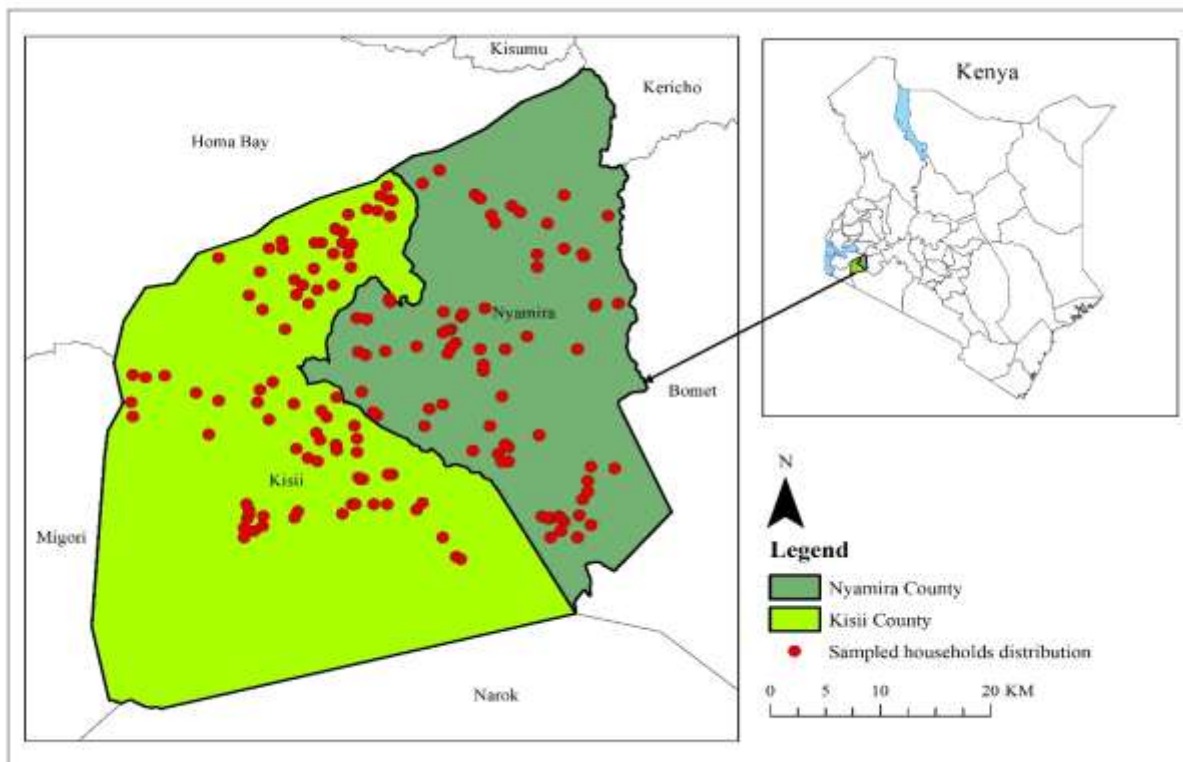
### **METHODOLOGY**

#### **3.1 Study area**

Data that was used for the purpose of the study was obtained from a field survey that was conducted in the counties of Kisii and Nyamira. The data was collected by Tegemeo Institute between July 2014 and October 2014. Kisii County shares borders with Nyamira County to the North East, Narok to the South, and Homabay and Migori Counties to the West. The County falls under the upper midland AEZ with altitude ranging between 1200 and 2100 metres above sea level. It has a total area of 1,332.7 square kilometres sub-divided into 9 sub-counties and 75 locations. Kisii County is estimated to have a population of 1,226,873 persons, consisting of 586,062 males and 640,811 females (KNBS, 2017). The county has a population density of 935 persons per square kilometre (KNBS, 2017). The county has a total of 913.84 km<sup>2</sup> of arable land, 190.66 km<sup>2</sup> of non-arable with water mass occupying about 18.4km<sup>2</sup>. The largest proportion of the arable land is used for agriculture with landholding size ranging between 0.2 to 2.1 acres as a result of land fragmentation (MOA, 2017). Kisii County also has forest cover which is approximated at 228.4 ha. The major agricultural activities in the county are banana and tea farming, produced as the main cash crops. There is also livestock farming with the majority of the farmers keeping cattle and sheep (MOA, 2017).

On the other hand, Nyamira County which borders Kisii to the West and Kericho to the East covers an area of 899.4 km<sup>2</sup>. The county is subdivided into 5 sub-counties, 38 locations and 90 sub-locations. Nyamira has a total population of 598,252 persons according to 2009 census report (KNBS, 2017). Out of the total area of the county, 90% is arable land. The larger portion of the arable land is used for small scale farming with an average holding of 1.75 acres. The county like Kisii has a hilly topography, and it lies on altitude of between 1,250 and 2,100 metres above the sea level (KNBS, 2017). The lower zones of the county are usually swampy and wetlands, but there are the upper zones which provide a favourable conditions for tea production which is the major cash crop in the area (MOA, 2017). The county also boasts of banana production as one of the cash crops as well as staple food for most families. Like in Kisii County, the farmers in Nyamira are smallholders and most of them practice small scale livestock rearing. The livestock includes cattle, chicken, goats, sheep, pigs among others (MOA, 2017). The study

focused on smallholder banana producers in the two counties. The Figure 3.1 illustrates the map for the study area and the distribution of the sampled households.



**Figure 3.1: The Map of the Study Areas and Sample Households Distribution**

Source: Drawn by the author using geo-points obtained from data collection households.

### 3.2 Data Source

The data was obtained from Tegemeo Institute of Agricultural Policy and Development. The data was collected in a household level survey conducted by the institution between July 2014 and October 2014.

### 3.3 Sampling procedure and data collection

The sample for the study was obtained from a two-stage stratified cluster sampling where the first stage involved selection of rural clusters from Kisii and Nyamira Counties. The process was done using Equal Probability Selection Method (EPSEM). The EPSEM method gives each individual equal chance of being selected for the study (Lavrakas, 2008). The clusters within the counties were listed in a census listing exercise by the Kenya National Bureau of Statistics

(KNBS) where both rural clusters as well as cluster populations were listed and assigned unique identifiers in a systematic manner. There were six main domain (strata) of interest during sampling procedure - the Agro-Ecological Zones (AEZs) that included: Upper Highlands (UH), Lower Highlands Upper Midlands (UM) – two zones, and Lower Midlands (LM) – two zones. The allocation of the sample to the AEZs was done using the square root allocation method to ensure that the smaller AEZs got an adequate sample. The square root allocation method is an optimum allocation method of sample in each stratum which takes into account the sizes of the strata and the variability within a strata. In order to obtain the minimum sampling variance the total sample size should be allocated to the strata proportionally to their sizes and also to the standard deviation of their values (Lavrakas, 2008).

$$n_h = \text{constant} \times N_h s_h \dots\dots\dots(1)$$

Where  $n$  is total sample size,  $n_h$  is the sample size in stratum  $h$ ,  $N_h$  is the stratum size  $h$  and  $s_h$  is the square root of the variance in stratum  $h$ .

Given that;

$$n = \sum_{h=1}^k n_h \dots\dots\dots(2)$$

in this case;

$$\text{Constant} = \frac{n}{\sum_{h=1}^k N_h s_h} \dots\dots\dots(3)$$

$$\text{So that; } n_h = n \cdot \frac{N_h s_h}{\sum_{h=1}^k N_h s_h} \dots\dots\dots(4)$$

The sample size for the rural clusters in each AEZ was calculated using the methodology to provide representative estimates for the main domain of interest. The second stage randomly selected a uniform sample of 20 households in each cluster from a roster of households in the cluster using a systematic random sampling method. From the overall sample size of farmers obtained from Kisii and Nyamira counties, the study was conducted using all the farmers who mentioned banana as one of their major crops. The selected banana farmers were categorized dependent on group participation, especially groups dominated by banana producers. As a result, a sample size of 260 smallholder banana producer households across the two counties were involved in the study. Out of that, 113 farmers (51 non-group and 62 group members) were interviewed in Kisii County, while 147 farmers (49 non-group and 98 group members) were interviewed in Nyamira County.

The data collection was done through a face to face approach using a Computer Aided Personal Interview econometric software. In which case the software was SurveyCTO. At the completion of every interview which was conducted at the household level, the interviewer recorded the Geo-point locations in front of every household. The geopoints obtained were used to draw the sample distribution across the two Counties as shown in figure 3.1. During data collection, there was no allowance for replacement of non-responding households. The survey was implemented between July and October 2014 and contained data for the 2013/2014 cropping year. Table 3.1 shows the distribution of households across the counties.

**Table 3.1: Sample Distribution Across the Counties Disaggregated by Wards**

County	Ward name	Sample size	non-group members	Group members
Nyamira	Ekerenyo	50	13	37
	Nyansiongo	50	22	28
	Manga	47	14	33
Total sample from Nyamira		147	49	98
Kisii	Keumbu	53	28	25
	Marani	60	23	37
Total sample from Kisii		113	51	62

Source: Tegemeo Institute Household Survey (2014).

### 3.4 Data analysis and presentation

The analysis of the data was done using descriptive statistics, logit model and stochastic frontier production function. The data analysis was done in Stata version 14.0.

**Table 3.2: Description of all Variables used in the Study**

Variable name	Description	Coding
<i>grppart</i>	Is farmer a group member?	0=No 1=Yes
<i>hsize</i>	Household size	
<i>age</i>	Age of the farmer (years)	
<i>educ</i>	Highest education level of the farmer	0=No formal education 1=Std1 2=std2 3=Std 3 4=Std 4 5=Std5 6=Std 6 7=Std 7 8=Std 8 9=Form 1 10=Form 2 11=Form 3 12=Form 4 13=Form 5 14=Form 6 15=College 1 16=College 2 17=College 3 18=College 4 19=University1 20=University 2 21=University 3 22=University 4 23=University 5 & above
<i>gender_head</i>	Gender of household head	0=Male 1=Female
<i>gender</i>	Gender of the farmer	0=Male 1=Female
<i>hhd_pos</i>	Relation to household head	1=Head 2=Spouse 3=Child 4=Worker
<i>marital</i>	Marital status of the farmer	0=Not married 1=Married
<i>sal</i>	Main farmer occupation is formal	0=No 1=Yes
<i>bus</i>	Main farmer occupation is informal	0=No 1=Yes
<i>ownradio</i>	Farmer own radio	0=No 1=Yes
<i>ownphone</i>	Farmer own mobile phone	0=No 1=Yes
<i>assetval</i>	Total asset value for household (Kes)	
<i>mnwage</i>	Household income (Kes)	
<i>facres</i>	Field size for banana production (acres)	
<i>mktkm</i>	Distance to nearest input market (Km)	
<i>ctmroad</i>	Condition of the road	1=worse 2=same 3=better

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<i>recadv</i>	Accessing extension advice	0=No 1=Yes
<i>cremntrec</i>	Amount of credit received (Kes)	
<i>hvst_acre</i>	total banana harvest per/acre (Kg)	
<i>manureqty</i>	Quantity of manure used/acre (Kg)	
<i>Fertqty</i>	Total quantity of fertilizer used (Kg)	
<i>fertuse</i>	Farmer used fertilizer in banana production	0=No 1=Yes

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Source: Tegemeo household survey, 2014.

### 3.4.1 Objective one: Determinants of group participation by the smallholder farmers

The objective was analysed using descriptive statistics that included establishing the mean, test for mean differences and standard deviation. Moreover, Logit model was applied to estimate the effects of various socio-economic characteristics on group participation as a form collective action among smallholder banana producers within the study areas. Logit model enables the handling of both ordinal and nominal independent variables. There was an assumption that the model has a nonlinear relationship between the dependent and independent variables. The study was based on the assumption that group membership depends on associated potential costs and benefits depending on the perception by different households. Costs such as opportunity of time and group membership fees could be some of the negative incentives, while better access to input markets, access to better technology and access to information could provide positive incentives for group participation.

Farmers in the two counties are also assumed rational in the decision and would only join collective action if the benefits would be higher than the costs. Consequently, decision by a household to participate in collective action was modelled in a random utility framework which has been commonly applied to evaluate adoption of innovations under uncertainty (Marra *et al.*, 2003). In the study, the decision by a banana producing household to participate in a group was modelled as a binary choice with assumption of utility maximization by the banana producer, subject to resource constraints (Manski, 1977).

A farmer would choose to join a group if the utility,  $U_c$  derived from group participation is higher than utility derived from non-participation,  $U_i$ . The utility  $U_i$  of a farmer in the study was expressed as a function of various household exogenous variables,  $X_i$  and a vector parameter  $\beta$ .

$$U_i = V_i(\beta X_i) + u_i \dots\dots\dots (1)$$

Where:  $u_i$  is the error term. Important to note is that group participation decision is affected by both external and internal household factors. Depending on the utility, the probability of a banana producer being group participant was therefore given by;

$$P(u_i < \beta X_i) \dots\dots\dots (2)$$

Which can be expressed in an equation as;

$$P(C = 1) = P(u_i < \beta X_i) = V_i(\beta X_i) + u_i \dots\dots\dots (3)$$

Where:  $P$  denotes probability,  $C = 1$  for group participant,  $C = 0$  for non-participant. According to the previous literature, the internal factors that were expected to influence farmer decisions were mainly farmer characteristics such as, age of the farmer, gender of the farmer, education level, household size and the marital status of the farmer among other covariates.

The external factors were expected to be access to extension, farm resources, among others (Sperandei, 2014). The general equation of logit model can be described as:

$$q(E(y)) = \alpha + \beta x_1 + \gamma x_2 \dots\dots\dots (4)$$

Where  $q$  is the link function,  $E(y)$  is the expectation of target variable and  $\alpha + \beta x_1 + \gamma x_2$  is the linear predictor ( $\alpha, \beta, \gamma$  are the coefficients). The model gives the probability of success or failure on the outcome of dependent variable, whereby the sum of the two possible outcomes must be equal to 1 (Sperandei, 2014).

Therefore by estimating the probability of success as  $P$ , then the probability of failure becomes  $1-P$ .

To derive the logit function, a simple regression equation is applied;

$$q(Y) = \beta_0 + \beta (X_i) \dots\dots\dots (5)$$

Where;  $y$  is the dependent variable and  $X_i$  are the dependent variables. The probability of success can be established by a general equation as;

$$P = \exp(\beta_0 + \beta(X_i)) = e^{(\beta_0 + \beta(X_i))} \dots\dots\dots (6)$$

In satisfying the condition that probability must be equal to or less than one, equation 6 is divided by a value more than 1.

$$p = \exp(\beta_0 + \beta(X_i)) / \exp(\beta_0 + \beta(X_i)) + 1 = e^{(\beta_0 + \beta(X_i))} / e^{(\beta_0 + \beta(X_i))} + 1 \dots\dots\dots(7)$$

The equation 7 gives probability as

$$p = e^y / 1 + e^y \dots\dots\dots(8)$$

The equation 8 is the logit function.  $P$  denotes the probability of success. The probability of failure was estimated from the equation 8 as;

$$1 - p = 1 - (e^y / 1 + e^y) \dots\dots\dots(9)$$

In addition to probability estimates from the logit model, the study went ahead to estimate the odds ratio of the outcome using logistic regression.

The odds ratio is always estimated from the logit model transformation by dividing equation 8 by equation 9

$$\text{Odds ratio} = P/(1-p) = e^y \dots\dots\dots(10)$$

By introducing log,

$$\text{Log} (P/(1-p)) = y \dots\dots\dots(11)$$

The logit model for the estimation of probability of group participation was generally expressed as

$$P(1,0) = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n + \mu \dots\dots\dots(12)$$

$$\mu \sim N(0,1).$$

In the study, the logit model was specified as;

$$\begin{aligned} P(\text{grppart}) = & \beta_0 + \beta_1 \text{gender} + \beta_2 \text{educ} + \beta_3 \text{marital} + \beta_4 \text{sal} + \beta_5 \text{bus} + \beta_6 \text{dmktkm} + \\ & \beta_7 \text{rcond} + \beta_8 \text{assetval} + \beta_9 \text{ownphone} + \beta_{10} \text{ownrad} + \beta_{11} \text{facres} + \\ & \beta_{12} \text{mnwage} + \beta_{13} \text{age} + \beta_{14} \text{hhd\_pos} + \beta_{15} \text{recadv} + \beta_{16} \text{hsize} + \\ & \beta_{17} \text{cramtrec} + \mu \dots\dots\dots(13) \end{aligned}$$

Variables used in the model are described in Table 3.3.

**Table 3.3: Variables used in the Logit model**

Variable name	Description	Expected effect
<i>grppart</i>	Is farmer a group member?	Dependent variable
<i>hsize</i>	Household size	+
<i>age</i>	Age of the farmer	+/-
<i>educ</i>	Highest level of education of farmer	+/-
<i>gender</i>	Gender of the farmer	+/-
<i>hhd_pos</i>	Relation to Household head	+/-
<i>marital</i>	Marital status of the farmer	+/-
<i>sal</i>	Main farmer occupation is formal	+/-
<i>bus</i>	Main farmer occupation is informal	+/-
<i>ownradio</i>	Farmer own radio	-
<i>ownphone</i>	Farmer own mobile phone	+
<i>assetval</i>	Total value of household asset (KES.)	+/-
<i>mnwage</i>	Off-farm income	+/-
<i>facres</i>	Field size (acres)	+/-
<i>mktkm</i>	Distance to nearest market (km)	+/-
<i>ctmroad</i>	Condition of the road	+/-
<i>recadv</i>	Farmer accessed extension advice	+

Source: Tegemeo Institute Household Survey (2014).

### 3.4.2 Objective two: Levels of technical efficiency by group participation

The scores of technical efficiencies were obtained using a stochastic frontier production function which is a two-stage estimation procedure. According to this function, the efficiency of a firm is defined as its actual productivity relative to maximal potential productivity (Farrell, 1957). The Stochastic Frontier Approach (SFA) allows the estimation of maximum attainable output for a given set of inputs. It also allows incorporation of other factors beyond input and prices in the model, thus reveals all factors that influence the producer's ability to become efficient (Dawn *et al.*, 2016). The parametric approach explicitly recognizes that production function represents a technically maximum feasible output level for a given level of farm inputs.

The function was derived from a Dobb-Douglas self-dual estimation function (Tijani, 2006). The production model was specified as below;

$$Y = f(x, \beta)e^{(v-\mu)} \dots\dots\dots (5)$$

Where Y is the output,  $f(x, \beta)$  denotes the frontier production function and  $v - \mu$  is the error term,  $v_i$  is a random variable assumed to have normal distribution  $N(0, \sigma^2v)$  and independent of  $\mu_i$  which is a non-negative random variable assumed to account for technical inefficiency. The two-stage estimation procedure stems from literature by Johnson (1964), who said that individual farm-specific characteristics which technical efficiency of decision-making units are not included in the conventional specification of the production function since they are not direct production units. The two-stage estimation will, therefore, allow incorporation of socio-economic characteristics since they have a roundabout effect on production, thus address the problem of endogeneity of group participation (Kalirajan & Shand, 1994). The first stage estimation will be used to analyse the second objective. Generally Technical Efficiency function is specified as;

$$TE_i = \frac{\sum X_{it} P_i}{\sum X_i P_i} \dots\dots\dots (6)$$

The function is however highly restrictive with respect to returns to scale and elasticity of production. Therefore, an unrestricted trans-log model of Maximum Likelihood Estimation (MLE) will be used to estimate the overall level of Technical Efficiency in the proposed study.

The general form of model will be specified as;

$$\ln Y = \beta_0 + \sum_{i=1}^n \beta_i \ln X_i + \sum_{i=1}^n \beta_i Z_i + \sum_{i=1}^n \sum_{i=1}^n \beta_i (\ln X_i)^2 + \sum_{i=1}^n \sum_{i=1}^n \beta_i (\ln Z_i)^2 + \sum_{i=1}^n \sum_{i=1}^n \beta_i \ln X_i \ln Z_i + \beta_k D_k + (v - u) \dots\dots\dots (7)$$

Where:  $\ln$  denotes natural logarithm, Z are conditioning factors, D is a dummy variable representing farmer and farm characteristics. The Elasticity of production of a given farmer  $i$  using  $j$  inputs will be determined by the equation below:

$$E_{ji} = \beta_j + \beta_{ji} \ln X_{1i} + \beta_{j2} \ln X_{2i} + \dots + \beta_{jn} \ln X_{ni} \dots\dots\dots (8)$$

In the proposed study, the model will be specified as:

$$\begin{aligned} \ln harvest\_acre = & \beta_0 + \beta_1 \ln field + \beta_2 \ln fert + \beta_3 \ln manure + \delta_1 (\ln field)^2 + \delta_2 (\ln fert)^2 \\ & + \delta_3 (\ln manure)^2 + \phi_1 \ln field * \ln fert + \phi_2 \ln field * \ln manure \\ & + \phi_3 \ln fert * \ln manure + (v - u) \dots \dots \dots (9) \end{aligned}$$

Where:  $\beta$ ;  $\delta$ ; and  $\phi$  are parameters for linear, quadratic and interactive terms respectively. The variables are described in Table 3.4.

To determine the factors which influence the level of technical inefficiency, the second stage of maximum likelihood estimation which incorporates household exogenous variables in the model.

The model was specified as:

$$\mu = \alpha_0 + \alpha_1 hsize + \alpha_2 educ + \alpha_3 gender + \alpha_4 sal + \alpha_5 bus + \alpha_6 mnwage + \alpha_7 age + \alpha_8 cramtrec + \alpha_9 assetval + \alpha_{10} recadv + \alpha_{11} marital + \varepsilon \dots \dots \dots (10)$$

Where:  $\mu$  denotes technical inefficiency scores. Level of significance of the results will be determined using t-statistics. The data was analysed using STATA version 14.0.

**Table 3.4: Variables used in the Stochastic Production Frontier Model**

Variable name	Description	Expected effect
<i>lnhvst_acre</i>	Log banana harvest per acre	Dependent variable
<i>fieldsize_log</i>	Log field size (acres)	+/-
<i>lnmanure</i>	Log quantity of manure used per acre	+
<i>lnfert</i>	Log quantity of fertilizer used per acre	+
<i>hsize</i>	Household size	+/-
<i>age</i>	Age of the farmer	+/-
<i>educ</i>	Highest level of education of farmer	+/-
<i>gender</i>	Gender of the farmer	+/-
<i>marital</i>	Marital status of the farmer	+/-
<i>sal</i>	Main farmer occupation is formal	+/-
<i>bus</i>	Main farmer occupation is informal	+/-
<i>assetval</i>	Total asset value (Kes.)	+/-
<i>mnwage</i>	Household income (kes)	+/-
<i>recadv</i>	Farmer received extension advice	+
<i>cramtrec</i>	Amount of credit received (Kes.)	-

Note. Adapted from Tegemeo Household Survey (2014).

## CHAPTER FOUR

### RESULTS

#### 4.1 Introduction

The section provides a detailed explanation of the results that were obtained from the data analysis. The results in the chapter were obtained using descriptive statistics, logit model and MLE model of the stochastic production frontier.

#### 4.2 Descriptive statistics for the socio-economic factors of smallholder banana farmers

Table 4.1 shows summary statistics for means and standard deviations of various socioeconomic factors the smallholder farmers that were obtained from the study. Disaggregated results the descriptive results show t-test results for the mean difference disaggregated by group membership for Kisii and Nyamira counties respectively.

In Kisii County, the average age of all the participants in the survey was 46.7 years old with a standard deviation of 12.9. It means that, the majority of the farmer's interview were aged between 34 and 50 years old. Out of the overall mean for the age of the farmers, disaggregation by group participation, the mean age of non-group participants was lower (41.7) with a standard deviation of 13.6, compared to that of group participants (50.8) with a standard deviation of 10.7. There was a statistically significant difference in the means of ages when disaggregated by group participation ( $p < 0.01$ ). That shows, group participants were of more statistically significant older age than their non-group members counterparts.

The results reveal that the overall mean for the gender of the farmer was at 0.5 that means, the sample size was non-bias against any gender. However, the disaggregated results show that the non-group participants relatively lower mean of 0.4 compared to group participants who registered a mean of 0.6. Considering that gender of the farmer was a binary variable coded as 0 for male and 1 for the female, the near zero mean for the non-group participants show that the majority of them were male. On the other hand the as the mean for the gender of group participants was closer to 1, that is evident that the majority of the group members (60%) were female, while male were 40%. The mean difference for gender was statistically significant at  $p < 0.05$ . The marital status of the farmers had a mean of 0.84 and 0.95 for non-group participants

and group participants respectively against an overall sample mean of 0.90. That means the majority of the respondents reported were married. That the disaggregated means show that there was a relatively higher number of farmers who were married among the group members as compared to non-group members. The difference in the mean for the marital status was statistically significant at  $p < 0.1$ . Marital status was coded as a binary variable with 0 for farmers who have never married (single) and 1 for married farmers, therefore the more the mean is closer to 1 the higher the number of married individuals in the sample.

The occupation, farmers who engage in informal types of occupation were found to be more likely to join groups. The results revealed that the majority of group participants were found to engage in business and other forms of informal income activities with a mean of 0.03 compared to 0.1 of non-group members with a statistically significant difference at  $p < 0.01$ . In overall, the mean of farmers engaged in informal occupations was 0.19. On the contrary, salaried workers were largely found among the non-group members with a mean of 0.34, against a mean of 0.29 for the group members. The difference was statistically significant at  $p < 0.01$ .

With regards to channels for access to information, the results also show that the majority of the farmers own radio at an overall mean of 0.6. The difference in means for ownership of radio categorised by group participation was not statistically significant. The overall mean of mobile phone ownership (a binary variable) was reported as 0.86, while the disaggregated means were 0.7 and 0.9 for non-group members and group members respectively. Access to extension services also showed a significant difference in mean with  $p < 0.05$ , whereby the group members reported a relatively higher mean of 1.0 compared to a mean of 0.9 for the non-members.

Other factors such as the total asset value, level of household income, distance to the market, amount of credit received did not show any significant difference after conducting t-test on mean difference by group participation. Table 4.1 shows a summary of the results for the descriptive statistics for the socio economic factors from the smallholder banana producers in Kisii County.

**Table 4.1: Summary Statistics for the Socioeconomic Factors among Farmers in Kisii County**

Variable label	Non-group members		Group members		test for mean difference			overall sample	
	Mean, (n=51)	SD	Mean, (n=62)	SD	MD	t value	p value	Mean (N=113)	SD
Household size	5.333	3.445	5.984	2.994	-0.650	-1.050	0.286	5.690	3.207
Age	41.726	13.649	50.806	10.729	-9.081***	-3.950	0.000	46.708	12.902
Gender	0.412	0.497	0.645	0.482	-0.233**	-2.500	0.013	0.540	0.501
Marital status	0.843	0.367	0.952	0.216	-0.108*	-1.950	0.053	0.903	0.298
Education level	10.098	4.442	10.290	3.185	-0.193	-0.250	0.789	10.204	3.787
Formal occupation	0.314	0.469	0.097	0.298	0.217***	3.000	0.004	0.195	0.398
Informal occupation	0.079	0.272	0.274	0.450	-0.196***	-2.750	0.007	0.186	0.391
Own radio	0.686	0.469	0.613	0.491	0.073	0.800	0.421	0.646	0.480
Own mobile phone	0.726	0.451	0.968	0.178	-0.242***	-3.900	0.000	0.858	0.350
Total asset value	1304.840	204.304	990.483	174.308	314.320	0.900	0.380	1632.345	188.270
Household income	2406.863	3095.901	3193.387	2862.532	-786.524	-1.400	0.164	2838.407	2982.658
Distance to the market	5.598	9.082	5.226	4.750	0.372	0.300	0.780	5.394	7.011
Credit	8.517	13.774	8.169	14.447	0.348	0.150	0.896	8.326	14.086
Received extension	0.902	0.300	1.000	0.000	-0.098**	-2.550	0.011	0.956	0.207

*Note.* Differences defined as column-line \* $p < .1$ ; \*\*  $p < .05$ ; \*\*\*  $p < .01$ . Age in years. SD=Standard Deviation. MD=Mead Difference. Yes=1 for formal occupation, informal main occupation, own mobile, own radio, received advice. Female=1 for gender. Married=1 for marital status. Total asset value, household income and credit received measured in '000Kes. No education=0 for education level. Source: Author's calculations using Tegemeo Institute Household Survey data (2014).

In the case of Nyamira County, the households had an overall household size mean of approximately 7 members with a corresponding standard deviation of 3.6. Additionally, the mean difference disaggregated by group participation showed significance level at  $p < 0.1$ . Group member households recorded a relatively higher mean of the household size (7 members) compared to non-group member households (6 members). The average age of all the participants in the survey was 47.5 years old with a standard deviation of 12.3. That means, the majority of the farmers interviewed in the county were aged between 33 and 50 years old. Comparison between average age of group members and the non-group members returned high levels of significance t-test ( $p < 0.01$ ) and a corresponding high t-value of 4.95. The disaggregated mean of the farmers' age of reported a lower mean for non-group participants was lower (40.79) with a standard deviation of 12.3, compared to that of group participants (50.8) with a standard deviation of 10.9. The t-test results is a justification that the group participants were of more significantly older than their non-group members counterparts.

The results reveal that the overall mean of the gender of the farmer was at 0.57 that means, the sample size was more or less gender balanced. However, the disaggregated results show that the non-group participants relatively lower mean of 0.5 compared to group participants who registered a mean of 0.6. However, the t-test for mean difference did not show any significant difference on the mean for gender by group participation. The marital status of the farmers had a mean of 0.84 and 0.95 for non-group participants and group participants respectively against an overall sample mean of 0.90. That means the majority of the respondents reported were married. That the disaggregated means show that there was a relatively higher number of farmers who were married among the group members as compared to non-group members. The marital status was did not show any significant difference in the mean between group and non-group participants. However, the results show that group participants had a higher mean (0.95) as compared to non-group participants (0.88) and an overall sample mean of 0.92. The values show that very large proportion of the farmers were married despite their status of group participation.

The overall mean of the highest level of education completed by the banana farmer was about 11.0, an equivalent of Form 3. The corresponding standard deviation was about 4.1 that means the majority of the farmers had completed between primary level education (standard 8) and O'

levels (form 4). Moreover, group members showed a statistically significant higher level of education ( $p < 0.1$ ) compared to non-group participants. In terms of the main occupation, both formal and informal types of occupation showed significant difference in the means between group and non-group members. The larger proportion of the non-group members engaged in formal occupation as their main activity, mean at 0.3 compared to group participants at a mean of 0.05. In overall only a mean of 0.14 was reported for the formal employed farmers. On the other hand, an overall mean of 0.22 was reported for informal employment, a show that many of the farmers were in informal employment. Non-group participants had a significant higher mean for formal employment (0.57) at  $p < 0.01$ , while their group counterparts reported significantly higher mean for informal occupation ( $p < 0.01$ ).

With regards to channels for access to information, the results show that the majority of the farmers in Nyamira county own radio at an overall mean of 0.6. The difference in means for ownership of radio categorised by group participation was statistically significant ( $p < 0.05$ ) with non-group members reporting higher mean (0.57) compared to group members (0.36). The mobile phone ownership also showed statistically significant difference between the means ( $p < 0.01$ ) classified by group participation. The mean of mobile phone ownership (a binary variable) among group members was significantly higher at 0.95 compared to a mean of 0.53 for the non-group members. The overall sample mean for mobile phone ownership was 0.9 that shows, very high proportion of the farmers had mobile phones. The average amount of credit received by the farmer showed a significant difference in mean disaggregated by group membership ( $p < 0.05$ ), where group members reported relatively higher mean credit value at KES8445.40 against KES1734.00 for non-group members. Access to extension services also showed a significant difference in mean with  $p < 0.01$ , whereby the group members reported a relatively higher mean of 0.7 compared to a mean of 0.1 for the non-members.

Factors such as the total asset value, level of household income, distance to the motor able road and the distance to the market, did not show any significant difference after conducting t-test on mean difference by group participation. The average asset value for the whole sample was KES13410.30 with a standard deviation of 20885.00. Non-group members recorded relatively higher mean asset value at KES14843.90 compared to the group members at KES12693.60. The

average household income was relatively higher among the non-group members at KES3300.00 compared to the non-group members at KES2998.90. The overall mean income reported was KES3099.30 with a standard deviation of 2837.20.

The average distance to the nearest market for the overall sample was 0.3km. The distance was averagely the same when disaggregated by group participation with both categories reporting a mean of around 0.3km. Table 4.2 shows a summary of the results for the descriptive statistics for the socio economic factors from the smallholder banana producers in Nyamira County.

**Table 4.2: Summary Statistics for the Socioeconomic Factors among Farmers in Nyamira County**

Variable label	Non-group members		Group members		test for mean difference			Overall sample	
	Mean, (n=49)	SD	Mean, (n=98)	SD	MD	t value	p value	Mean (N=147)	SD
Household size	5.959	3.208	7.184	3.701	-1.224*	-1.950	0.051	6.776	3.580
Age	40.939	12.326	50.776	10.876	-9.837***	-4.950	0.000	47.497	12.255
Gender	0.49	0.505	0.602	0.492	-0.112	-1.300	0.199	0.565	0.498
Marital status	0.878	0.331	0.949	0.221	-0.072	-1.550	0.122	0.925	0.264
Education level	10.123	4.428	11.408	3.948	-1.286*	-1.800	0.076	10.980	4.144
Formal occupation	0.327	0.474	0.051	0.221	0.276***	4.800	0.000	0.143	0.351
Informal occupation	0.041	0.200	0.317	0.467	-0.341***	-3.950	0.000	0.224	0.419
Own radio	0.572	0.456	0.367	0.494	0.204**	2.400	0.018	0.633	0.484
Own mobile phone	0.53	0.407	0.959	0.173	-0.429***	-7.350	0.000	0.912	0.285
Total asset value	1484.878	2054.020	1269.357	2112.340	2150.307	0.600	0.558	1341.034	9185.070
Household income	3300.000	3199.805	2998.979	2649.353	301.021	0.600	0.546	3099.320	2837.216
Distance to the market	3.017	2.112	3.317	1.883	-0.300	-0.900	0.383	3.217	1.960
Credit	173.443	4993.312	8445.408	17713.77	-6,703.00**	-2.550	0.012	6270.000	1514.150
Received extension	0.102	0.306	0.7245	0.449	-0.6225***	-8.75	0.000	0.517	0.501

*Note.* Differences defined as column-line \*p<.1; \*\* p<.05; \*\*\* p<.01. Age in years. MD=Mean Difference. SD=Standard Deviation.

Yes=1 for formal occupation, informal main occupation, own mobile, own radio, received advice. Female=1 for gender. 1=married for marital status. Total asset value, household income and credit received measured in '000Kes. No education=0 for education level.

Source: Author's calculations using Tegemeo institute household survey data (2014).

Finally, Table 4.3 gives a summary of descriptive statistics of variables related to banana production. From Table 4.3, the average field size under banana production for Kisii county farmers did not show statistical significance in mean difference between group participants and non-group participants. In overall the mean field size was 0.4 acres with a standard deviation of 0.35 that shows the majority of the farmers planted bananas in an area ranging from 0.1 acres to 0.75 acres. The farmers were asked whether they used any form of fertilizer on banana production whereby group members returned a mean of 0.5 to the dummy variable as non-group members returned a low mean of 0.56. The difference in mean was statistically significant at  $p < 0.05$  respectively. Use of inorganic fertilizer and organic manure also returned a significant difference at  $p < 0.05$  respectively. In both cases group members registered higher mean quantities for inorganic fertilizer (1.77kg) and organic manure (145kg), compared to non-group members at about 0.14kg and 57kg for inorganic and organic fertilizers respectively. In Kisii County, there was no significant difference in productivity levels of banana disaggregated by group participation.

In Nyamira County, the mean land size was 0.41 with a corresponding standard deviation of 0.4. The land size did not return significant difference in means when categorized by group participation. On whether the farmers applied any form of fertilizer on banana production, group members returned a mean of 0.5 to the dummy variable as non-group members turned low mean of 0.2. The difference in mean was statistically significant at  $p < 0.05$ . Use of organic manure also returned a significant difference at  $p < 0.05$  with group members registering a higher mean of 167.6kg against an overall mean of 128.3kg. In Nyamira County, there was no significant difference in productivity levels of banana when disaggregated by group participation. Table 4.3 and 4.4 shows summary of the results of summary statistics for production factors from Kisii and Nyamira.

**Table 4.3: Banana Production Factors Descriptive Statistics for Kisii County**

Variable label	Non-group members		Group members		test for mean difference			Overall sample members	
	Mean (n=51)	Std Dev	Mean (n=62)	Std Dev	mean difference	t value	p value	Mean (N=113)	Std Dev
Field size	0.421	0.399	0.388	0.310	0.033	0.500	0.626	0.403	0.352
Fertilizer used	0.294	0.460	0.500	0.504	-0.206**	-2.250	0.026	0.407	0.493
Total quantity of fertilizer (Kg)	0.147	0.862	1.766	5.257	-1.619**	-2.150	0.032	1.035	4.005
Total quantity of manure used (kg)	57.098	126.925	144.807	233.079	-87.708**	-2.400	0.018	105.221	196.729
Banana harvest per/acre (Kg)	592.806	678.565	693.192	438.760	-100.386	-0.950	0.345	647.885	559.397

*Note.* Differences defined as column-line \*p<.1; \*\* p<.05; \*\*\* p<.01. Field size measured in acres. Yes=1 for fertilizer use.

Source: Author's calculations using Tegemeo institute household survey data, 2014.

**Table 4.4: Production Factors Descriptive Statistics for Nyamira County**

Variable label	Non-group members		Group members		test for mean difference			Overall sample	
	Mean (n=49)	Std Dev	Mean (n=98)	Std Dev	mean differen ce (m1- m2)	t value	p value	Mean (N=147)	Std Dev
Field size	0.333	0.283	0.450	0.453	-0.117	-1.65	0.103	0.411	0.407
Fertilizer used	0.265	0.446	0.531	0.502	-.266**	-3.15	0.002	0.442	0.498
Total quantity of fertilizer (Kg)	0.561	2.135	1.622	4.621	-1.061	-1.55	0.129	1.268	3.992
Total quantity of manure used (kg)	49.633	127.7 17	167.643	268.04 5	- 118.01*	-2.9	0.004	128.3 06	237.0 94
Banana harvest per/acre (Kg)	749.60 8	865.2 98	1100.66 7	1558.0 48	-351.059	-1.45	0.144	983.6 48	1373. 512

*Note.* Differences defined as column-line \*p<.1; \*\* p<.05; \*\*\* p<.01. Field size measured in acres. Yes=1 for fertilizer use.

Source: Author's calculations using Tegemeo Institute Household Survey Data, 2014.

### 4.3 Determinants of group participation by smallholder banana producers

The first objective of the study was to determine the household socioeconomic characteristics that influence their decision for group participation. The factors were determined through a logit model to show the coefficient of association between the group participation and the various covariates. Further, the logistic regression was used to show the Odds Ratio (OR) of the outcome of interest (group participation) given exposure to various socioeconomic variables (Hoppe et al., 2018). The variables used in the model were: age of the household head, household size, household income, level of education attained, gender of the farmer, relationship to the household head, field size, main salaried occupation, main informal occupation, condition of the road, distance to the market, distance to motor able road, phone ownership, radio ownership, access to extension advice, and the total asset value of the household.

The results by logit model from Kisii county showed a highly significant association between group participation and household socioeconomic characteristics with Prob.> chi2= 0.000 and the pseudo  $R^2 = 0.268$ . Age of the farmers in Kisii had a positive significant effect of its coefficient on the group participation ( $p < 0.05$ , OR=1.05). The analysis obtained similar results from marginal effect prediction model where age had a p-value < 0.05. Although the logit model did not return statistically significant effect for the coefficient for gender, the results obtained from the odds ratio showed high association between gender and group participation (OR=2.2). Similar results were observed on the marital status as well as informal form of occupation, where coefficient was positive, but not significant, while the odds ratios were 3.68 and 3.58 respectively. On the contrary, the marginal effect returned significant association for both informal and formal occupation ( $p < 0.05$ ). Farmers who own mobile phones showed high positive association with group participation where the coefficient was significant at  $p < 0.01$ , OR=11.6). The marginal effect further showed that mobile phone ownership was a major predictor of group membership with a p-value < 0.001. The constant value was significant at  $p < 0.01$  with a negative impact on group participation. The base margin for the constant was equally significant at  $p < 0.001$ .

Among the farmers in Nyamira County, logit model revealed a negative association between relationship to the household head and group participation, however the odds ratio was below 1.

Gender of the farmer had a strong positive association with the group participation ( $p < 0.01$ ,  $OR = 8.29$ ). Coefficient of formal occupation had a negative impact on group participation with  $p$ -value  $< 0.01$ . Informal occupation on the other hand had a positive association with group participation where the coefficient was statistically significant at  $p < 0.01$  and associated  $OR$  of 7.19. Mobile phone ownership had a positive association with group participation with the  $p$ -value  $< 0.05$  and a corresponding odds ratio of 4.48. Further results show that, in areas where the condition of the road was worse compared to the previous years, the farmers were more likely to join producer groups ( $p < 0.01$ ). Groups that offered more extension services were more likely to attract farmers to join them. Access to extension services returned a high level of positive association with group participation at  $p$ -value  $< 0.001$  and  $OR = 9.48$ . Despite the fact that field size did not show significant effect on group participation from the coefficient value, the odd ratio of 2.87 is a proof that the more the exposer to bigger land size, the higher the likelihood of group participation. The  $Prob. > \chi^2 = 0.000$  shows good association between the covariates and group participation among the farmers in Nyamira county. The marginal effects after the regression model to predict the level of change associated with a unit change in the covariates returned significant effects for access to extension services ( $p < 0.05$ ) and base margin at  $p < 0.001$ . The results of the logit model and respective odds ratio are summarized and presented in the Tables 4.5 and 4.6 for Kisii and Nyamira counties respectively.

**Table 4.5 : The Determinants of Group Participation by the Producers in Kisii County**

Variable	Logit model results				marginal effect	
	Coeff	OR	SE	P>z	margins	P>z
Relationship to the head (1=Head)	-0.194	0.824	0.084	0.700	-0.036	0.752
Household size	0.062	1.064	0.504	0.460	0.015	0.449
Age of the farmer	0.039	1.039	0.021	0.066	0.012	0.019
Gender of the farmer (1=female)*	0.883	2.419	0.571	0.122	0.188	0.168
Marital status of the farmer (1=married)*	0.226	1.253	1.277	0.860	0.312	0.142
Education level of the farmer (1=lowest level)	0.000	1.000	0.074	0.996	0.018	0.331
Main occupation is formal (1=yes)*	-1.949*	0.142	0.766	0.011	-0.335	0.034
Main occupation is informal (1=yes)*	0.414	1.513	0.716	0.563	0.272	0.031
Farmer own radio (1=yes)*	-0.240	0.787	0.549	0.663	-0.090	0.482
Farmer own mobile phone (1=yes)*	2.438**	11.446	0.753	0.001	0.516	0.000
Total asset value (1000Kes)	0.000	1.000	0.000	0.969	0.000	0.915
Household income (1000kes)	0.000	1.000	0.000	0.713	0.000	0.708
Distance to the market (km)	0.025	1.025	0.053	0.639	0.003	0.799
Condition of the nearest road(1=worse)	0.011	0.999	0.286	0.982	-0.069	0.268
Amount of credit received (Kes)	0.000	1.011	0.000	0.969	0.000	0.911
Received extension advise (1=yes)*	(omitted)	1.000	(omitted)	0.999		
Field size for banana production (acres)	-0.545	1.000	0.778		-0.123	0.539
Constant	-3.915	0.580	2.191	0.484	0.574	0.000
LR chi2(19)	44.280			0.074		
Prob > chi2	0.000					
Pseudo R2	0.301					
Number of observation	108					

Note. \* p<.05; \*\* p<.01; \*\*\* p<.001. (\*) dy/dx is for discrete change of dummies from 0 to 1. S.E = standard error, Coeff= logit model coefficient, OR=Odds Ratio, SE=Standard Error.

Source: Author's calculations using Tegemeo institute household survey data, 2014.

**Table 4.6: The Determinants of Group Participation by the Producers in Nyamira County**

Variable	Logit model results			marginal effect		
	Coeff	OR	SE	P>z	margins	P>z
Relationship to the head (1=Head)	-2.625*	0.072	1.132	0.020	0.00	0.58
Household size	0.018	1.018	0.141	0.900	-0.05	0.25
Age of the farmer	0.045	1.046	0.035	0.200	0.00	0.35
Gender of the farmer (1=female)*	3.610**	8.290	1.149	0.002	0.12	0.86
Marital status of the farmer (1=married)*	0.301	1.352	1.594	0.850	0.00	0.97
Education level of the farmer (1=lowest level)	0.098	1.103	0.131	0.451	0.00	0.57
Main occupation is formal (1=yes)*	-5.184*	0.006	2.018	0.005	-0.42	0.13
Main occupation is informal (1=yes)*	6.800*	7.186	2.895	0.005	0.10	0.09
Farmer own radio (1=yes)*	-1.945*	0.121	0.950	0.057	-0.04	0.26
Farmer own mobile phone (1=yes)*	3.611*	4.484	1.627	0.027	0.44	0.20
Total asset value for the household (Kes)	0.000	1.000	0.000	0.372	0.00	0.43
Household income (1000kes)	0.000	1.000	0.000	0.426	0.00	0.49
Distance to the market (km)	0.453	1.573	0.278	0.220	0.01	0.32
Condition of the nearest road(1=worse)	-1.047	0.351	0.674	0.006	-0.05	0.17
Amount of credit received (1000Kes)	0.000	1.000	0.000	0.360	0.00	0.44
Received extension advise (1=yes)*	4.591***	9.467	1.220	0.000	0.35	0.01
Field size for banana production (acres)	2.561	2.871	1.723	0.095	0.09	0.19
Constant	-5.165	0.009	3.63	0.169	0.68	0.00
LR chi2(19)	128.87					
Prob > chi2	0.000					
Pseudo R2	0.705					
Number of observation	145					

Note. \* p<.05; \*\* p<.01; \*\*\* p<.001. (\*) dy/dx is for discrete change of dummies from 0 to 1.

S.E = standard error, Coeff= logit model coefficient, OR=Odds Ratio, SE=Standard Error.

Source: Author's calculations using Tegemeo institute household survey data, 2014.

#### **4.4 Technical efficiency levels of banana producers by group participation**

Estimation of the technical efficiency levels from the study was done using the stochastic frontier approach. The model allows the simultaneous estimation of factors which affect farm-level productivity as well as household covariates which are responsible for farm inefficiencies. From the results which were generated using a truncated form of maximum likelihood estimation, the results showed consistency with a number of previous empirical studies to estimate factors affecting farm level technical efficiency levels. In the first stage of estimation, production inputs were incorporated in the model, which were: field size in acres, fertilizer in kilograms and quantity of organic manure used in kilograms. While executing the model, the interaction variable between fertilizer and manure for non-group members showed multi-collinearity and was dropped from the regression analysis.

From the data obtained from both Kisii and Nyamira counties, 99% of the banana producers used a local variety as the planting material, thus the variable was not included in the analysis because it lacked variability. Results from both Kisii and Nyamira County from a truncated normal distribution returned the very low gamma, less than 0.1 for the non-group and group participants respectively. The low levels of gamma imply that the deviations in banana output are huge as a result of factors other than inefficiency in input use by smallholder farmers. The factors are believed to be random shocks which are beyond the control of the farmer such as climatic factors, pests and disease infestation and statistical errors. From the gamma estimates, it could be seen that non-collective action participants are more susceptible to effects of random shocks than their counterparts who subscribe to collective action. The result was expected as group members are likely to gain more and better skills in dealing with prevailing adverse climatic conditions and any other uncertainty in the course of production. The impact of production factors in the farm productivity levels in both Kisii and Nyamira counties is shown in Table 4.7.

For Kisii county, the results showed that, the size of the banana fields had a positive significant influence in productivity levels for both the group participants and non-participants ( $p < 0.001$ ). For group participants, the elasticity for field size was 1.39 that implies any unit increase in the field under banana crop, productivity would increase more proportionately by 139%. Non-group members registered a relatively lower elasticity for field size at 0.62 increasing the field size to

higher level (field size squared) still gave a positive significant coefficient for the group and a negative effect for the non-group members. To note, group members recorded high levels of association at  $p < 0.001$  and elasticity of 0.2, while their counterparts recorded significant levels at  $p < 0.05$  and a positive elasticity of productivity of 0.08. Small quantities of fertilizer did not return any significant effect on productivity levels, however increased amounts of fertilizer by obtaining the squares showed significant effect on the productivity levels at  $p < 0.05$  for group members. Similarly, higher quantities of manure obtained by squaring the quantities of organic manure used gave statistically significant effects on levels of productivity for both farmer categories. Non-group participants revealed a higher association ( $p < 0.001$ ) and a corresponding higher elasticity of production (0.06), in relation to group participants whose elasticity of production (0.02) was statistically significant at  $p < 0.05$ . Interaction between field size and fertilizer returned a positive significant effect on productivity levels at  $p < 0.05$  and an elasticity of production of 0.18 for the group members.

With regards to farmers in Nyamira county, the size of the banana field also had a positive significant influence in productivity levels for both the group participants and non-participants at  $p < 0.01$  and  $p < 0.05$  respectively. For group participants, the elasticity for field size was 0.49, non-group members registered a relatively higher elasticity for field size at 0.66. The field size squared reported a positive significant coefficient for the group members only with  $p < 0.001$  and a 0.85 returns to scale. Results for the square of the amount of fertilizer was similar to that of the square of the field size, as it was gave significant levels of association with higher productivity for the group members with a  $p$ -value  $< 0.01$  and 32% elasticity levels. Higher quantities of manure used revealed a statistically significant effects on levels of productivity for the group participants where  $p$ -value was less than 0.05 and a higher coefficient of elasticity of 1.42. Interaction between field size and fertilizer returned mixed results for group members and non-group members respectively. The latter variable had a positive significant effect on productivity levels at  $p < 0.05$  and an elasticity of production of 0.64 for the group participants, whereas at the same time, it had a negative effect for the non-group participants ( $p < 0.05$ ). In both Kisii and Nyamira, the constant value of the model remained highly significant with a positive effect on productivity at a  $p < 0.001$ . In addition, in both counties the standard errors of each of the variables in the model for both the group and non-group members were less than 1.0 that depicts

the points were closer to the predicted curve, thus better fit. The results for the factors that determine banana productivity are summarized in the Table 4.7.

**Table 4.7: Stochastic Frontier Model Estimates by Group Participation**

Variable	Kisii county				Nyamira county			
	Non-group participants		Group participants		Non-group participants		Group participants	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Log field size	0.62***	0.298	1.329***	0.199	0.662*	0.078	0.479**	0.183
Log field size squared	-0.079*	0.063	0.226***	0.051	-0.324	0.141	0.846***	0.043
Log quantity of fertilizer	1.185	0.724	0.357	0.103	1.185	0.832	0.096	0.090
Log quantity of fertilizer squared	0.009	0.326	0.121*	0.067	0.009	0.096	0.321**	0.075
Log quantity of manure	-0.108	0.198	-0.016	0.188	-0.338	0.248	-0.022	0.259
Log quantity of manure squared	0.057***	0.035	0.027*	0.031	0.137	0.084	1.417*	0.060
Log field-fertilizer interaction	-0.535	0.163	0.175*	0.110	-0.043*	0.163	0.635*	0.231
Log field-manure interaction	-0.053	0.039	-0.018	0.028	-0.053	0.039	-0.132	0.168
Log fertilizer-manure interaction	0.016	0.024	0.004	0.027	0.016	0.024	0.032	0.039
Constant	3.149***	0.264	7.624***	0.257	3.701**	0.364	4.024***	0.176
gamma	0.017		0.092		0.022		0.073	
Log-likelihood	-87.571		-91.428		-27.571		-55.10	
Number of observations	51		62		49		98	

Note. \* p<.05; \*\* p<.01; \*\*\* p<.001. Coeff=Coefficient. SE=Standard Error

Source: Author's calculations using Tegemeo institute household survey data, 2014.

In the estimation of technical efficiency from stochastic production frontier, the distribution of the technical efficiency levels in Kisii County revealed minimum level of 0.5. Approximately 2.2% and about 3.7% of non-group members and group members respectively were at most 60% technically efficient. The overall proportion of farmers in Kisii whose efficiency levels were between 0.5 and 0.6 were about 3.1%. The larger proportion of group members (72%) in Kisii were at least 80% technically efficient with about 44% recording at least 90% efficiency levels. On the other hand, non-group participants had around 60% of the farmers being at least 80% technically efficient. In the case of Nyamira County, the lowest reported technical efficiency level was 0.5 just as the case in Kisii. Grouped technical efficiency levels saw approximately 1% of the overall sample falling 60% of efficiency levels. About 77% of the group members were at least 80% technically efficient, as compared to about 69% of non-group members. In overall, about 73.5% of the farmers in Nyamira had technical efficiency levels above of 80%. Table 4.8 gives a summary of the proportion of farmers in different groups of technical efficiency categorized by group participation.

**Table 4.8: Technical efficiency levels of the producers by group participation**

	Kisii County			Nyamira County		
	Non-group	Group	Overall	Non-group	Group	Overall
	participants	participants		participants	participants	
Grouped TE Scores	%	%	%	%	%	%
$0.5 \leq 0.6$	2.21	3.68	3.12	1.72	0.00	1.01
$0.6 \leq 0.7$	13.10	9.18	12.05	9.38	7.44	8.34
$0.7 \leq 0.8$	25.00	15.01	20.10	19.55	15.78	17.15
$0.8 \leq 0.9$	22.55	28.03	23.03	25.00	25.21	25.24
$0.9 \leq 1.0$	37.14	44.10	41.70	44.35	51.57	48.26

*Note.* TE= Technical efficiency.

Source: Author's calculations using Tegemeo institute household survey data (2014).

#### **4.5 Test for the test for difference in mean technical efficiency levels by group membership**

According to the predicted technical efficiency, Kisii County had an overall mean of 0.87. The group members from the county were more technically efficient with a higher mean of 0.89, while the non-participants had a mean of 0.85. In Nyamira, the observation was the similar to Kisii County as group members were better technically efficient than their non-group members' counterparts. The average technical efficiency for the group members in Nyamira county was estimated at 0.81, while that of non-members was at 0.85 against an overall sample mean of 0.83. The test for mean difference disaggregated by group participation in the two counties gave a statistically significant difference at  $p\text{-value} < 0.01$ . Table 4.9 provides a summary of the results.

**Table 4.9: Test for Difference in Mean Technical Efficiency Levels by Group Participation**

Farmer category	Type of statistic	Kisii county	Nyamira county
Non-group members	Mean, m1	0.85	0.81
	SD	0.08	0.04
Group members	Mean, m2	0.89	0.85
	SD	0.12	0.10
	t-test for mean difference	-0.05**	-0.04***
overall sample	overall mean	0.87	0.83
	SD	0.10	0.09

*Note.* Differences defined as column-line \* $p < .1$ ; \*\*  $p < .05$ ; \*\*\*  $p < .01$ . SD=standard deviation

Source: Author's calculations using Tegemeo institute household survey data (2014).

#### 4.5 Sources of technical inefficiency of banana producers by group participation

Estimation of sources of technical inefficiency was done by second-stage estimation of MLE where household covariates were incorporated in the model. The covariates included: household size, age of the farmer, gender of the farmer, informal occupation, salaried occupation, education level of the farmer, household income the marital status of the farmer and access to extension advice. It was expected that these factors would influence a farmer's decision, thus inefficiency level. The results from Kisii county show that, age of the farmer, formal occupation and informal occupation had significant effects of technical inefficiency levels among non-group members. The age and informal employment had a negative effect on technical inefficiency at  $p < 0.01$  and  $p < 0.05$  respectively. Formal (salaried) occupation revealed a positive effect on the non-group members at  $p < 0.05$ . The group members in Kisii County showed significant effect with gender and age of the farmer. Both gender and the age of the farmer had a negative influence on technical inefficiency levels for the group participants. The age was statistically significant at  $p < 0.001$ , while the gender at  $p < 0.01$ .

In Nyamira, the inefficiency levels showed significant relation with the age and informal occupation of the farmer amongst both the group and non-group members. For age, older farmers were lesser technically inefficient at  $p < 0.001$ , whereas informal employment had a negative statistically significant at  $p < 0.05$ . Besides, group members' technical efficiency levels were

significantly affected by gender and access to extension services. The covariates showed a negative effect on the inefficiency for the group members, whereby the gender was statistically significant at  $p < 0.01$  and access to extension services at  $p < 0.05$ . The results of the sources of inefficiency among farmers are presented in Table 4.10 below

**Table 4.10: Sources of Technical Inefficiency among the Smallholder Farmers**

Variable	Kisii county				Nyamira county			
	Non-group member		Group member		Non-group member		Group member	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Constant	-0.30	0.55	0.00	0.71	-0.44	0.55	0.27	0.62
Household size	-0.57	0.46	0.19	0.35	0.74	0.46	0.22	0.07
Age of the farmer	-0.02**	0.00	-0.04***	0.01	-0.24***	0.02	-0.15***	0.13
Highest education level	0.70	0.04	0.09	0.03	0.83	0.01	0.54	0.07
Gender of farmer	-0.08	0.14	-0.01**	0.18	-0.32	0.14	-0.11**	0.41
Marital status of the farmer	0.21	0.28	0.38	0.53	0.68	0.28	0.04	0.26
Formal main occupation	0.26*	0.15	0.03	2.69	0.54	0.15	-0.05	1.38
Informal main occupation	-0.31*	0.15	0.00	0.01	-0.17*	0.15	-0.48*	0.04
Access to extension advise	0.02	0.14	0.06	2.55	0.11	0.14	-0.18*	2.11
Household income (1000Kes.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total asset value (1000Kes.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Credit received (kes)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total observations	51		62		49		98	

*Note.* \* p<.05; \*\* p<.01; \*\*\* p<.001. Coeff=coefficient. SE=standard error

Source: Author's calculations using Tegemeo institute household survey data, 2014.

## **CHAPTER FIVE**

### **DISCUSSION**

#### **5.1 Introduction**

In this chapter, the author provides a detailed interpretation and discussions of the results obtained during the study supported by relevant literature from the recent studies.

#### **5.2 Discussion of the determinants of group participation by the smallholder producers**

The results from the Table 4.6 and 4.7 presents various factors that show significant level of influence on the decision of the banana producers in Kisii and Nyamira to join or not join producer groups. The results from the areas show a good model fit going by the value of standard errors that are very low (Fagerland & Hosmer, 2016). Relationship of the farmer to the household head had a significant negative impact on group participation among producers in Nyamira County. That is a proof that in cases where the person who was responsible for banana production was the household head, there was higher likelihood that the farmer would join a group. The direction of the association between household head and group participation was as expected from the study. First, the household head is the final decision maker in a household, thus they face little or no barrier when they decide to subscribe to group membership.

On the contrary, other members of the household would not have the privilege to join groups at will without approval from the head. Second, it this the household head who bears the greatest responsibility in socioeconomic obligations in the household, that makes it rational that they would want to join such institutions to improve the socioeconomic welfare for their households. A number of previous studies established consistent results on the influence of household head in collective action through group participation (Fischer & Qaim, 2014). The coefficient of the age of the farmer showed a positive association with the probability of group participation at  $p < 0.05$  amongst the farmers from Kisii County. The odds ratio associated with age was also slightly greater than 1 which affirms that the group participation is positively influence by increase in the age of the farmer (Hoppe et al., 2018; Melati et al., 2020). The results are justified in relation to choice for farming as occupation, which has a negative correlation with farmer's age. The majority of younger population in many cases disregard farming as a source of employment and instead move to urban areas to seek for alternative sources of income (Khanal et al., 2021). A

relatively larger proportion of older population are left in the rural areas engaging in farming as their main occupation, thus higher likelihood of finding older farmers dominating agricultural production related groups (Mutonyi, 2019). The finding was consistent with similar findings of earlier studies where age had a positive correlation to likelihood of group participation (Khanal et al., 2021; Melati et al., 2020). According to Lwazeura & Ngaruko (2013), and Abate et al. (2014), the majority of younger population preferred to look for other sources of employment than engage in agricultural activities. From the result, it is clear that young people especially the male are yet to fully embrace agribusiness, or engage in agricultural activities as source of livelihood.

Gender of the farmer also had a highly significant association with group participation in Kisii and Nyamira counties. Whereas the coefficient showed female farmers strongly associated with group membership than their male counterparts ( $p < 0.001$ ) in Nyamira, the coefficient result was echoed by the high odds ratios in both counties for the gender covariate that showed that female gender exposure would result in higher chances for participation (Hoppe et al., 2018). In Kenya banana production has been highly associated with women, therefore the study expected that most of the farmers participating in groups would be women (Kabunga, 2012). In previous studies, the female gender was more likely to participate in collective action compared to male counterparts. Women prefer to build more social ties than men, which motivate them to engage in a group as a way of building social ties with other women (Angon et al., 2021).

Logistic regression result returned higher odds for group participation on marital status, especially in Kisii County. As found out in relevant literature, married farmers tend to have more economic obligations to fend for the families that makes them look for avenues to improve their capital and economic welfare. As a result, they are more likely to venture into farming activities as a source of food and income, and by extension engage in building social capital with an objective of improving their households' welfare (Angon et al., 2021). The coefficient of formal and informal occupation returned significant effect in Nyamira County at  $p < 0.01$ , however the two covariates had opposite direction on the influence on group participation. As the farmers whose main occupation were formal revealed a higher likelihood of pursuing their production goals individually, informal occupation showed positive results towards group approach. The

study attributes the negative impact of salaried occupation on group participation to the opportunity cost of time. Important to note, is that most salaried individuals are employees under lesser flexible timetable. Therefore, the majority of such employees do not find time to attend group meetings. Additionally, salaried employees are relatively more likely to access credit facility by committing the pay slips as collateral security, as opposed to those farmers who are involved in informal income activities. On the other hand, farmers in informal businesses and other casual work (*vibarua*) draw their incentive to engage themselves on group activities in anticipation of benefiting from the social capital, from which they would enhance their chances of access to inputs, credit facility, and production information. The results were consistent from a number of previous studies, which had similar findings (Angon et al., 2021; Mutonyi, 2019).

Regarding information access, the study found that mobile phone ownership had a strong positive and significant effect on the likelihood of banana group participation ( $p < 0.001$ ) and corresponding high odd ratio (odds ratio  $> 4$ ) in both counties. The results are plausible because a farmer who owns a mobile phone can access information easily regarding scheduled meetings. According to Fischer & Qaim (2014), and Angon et al. (2021), banana producers who own mobile phones are easy to contact and given information regarding group formation, and notification about group meetings. The high odds ratio further confirm that mobile phone ownership is a great influencer in reaching out to and mobilizing farmers to attend meetings.

Poor road conditions had a positive influence on group participation among the farmers in Nyamira County. As already established in other studies, a road in bad condition increases farmers' production and marketing costs in a number of ways. Firstly, it increases the time taken to reach the input market that indirectly implies longer distance in terms of time. Secondly, it leads to higher cost of transportation due to time and mechanical problems brought about by such conditions. Therefore, similar to physical distance to the market, condition of the road would influence group participation. The findings are consistent with findings by Fischer and Qaim (2014), where time taken to reach the market had a positive association with group participation.

Finally, access to extension advice increased the probability of group participation by a household ( $P < 0.001$ ) with a corresponding odds ratio of 9.5. Groups that provide easy access to extension advice attracts more members because it reduces the cost of information access and at the same time enhance farmer's awareness and informed decision making during production (Angon et al., 2021; Ombogoh et al., 2018). The high odds ratio showed that when farmers realize there is value in a group, they would be attracted to such associations (Mutonyi, 2019)

### **5.3 Discussion of technical efficiency levels of the banana producers**

In the section, the results for the levels of technical efficiency of the the banana producers are discussed to relate them to existing empirical evidence. The section also discusses the findings on the factors affecting productivity to the recent available literature.

#### **5.3.1 Factors affecting productivity levels banana among the banana producers**

Land size had a positive and statistically significant effect across the two counties for both group and non-group members as illustrated in Table 4.8. The finding on land size was consistent with other previous literature where increase in the acreage under banana increased the productivity levels (Ayinde et al., 2015). In a similar study, Ngango & Kim (2019) found land consolidation to be a positive influencer of technical efficiency of smallholder farmers. However, for non-group members in Kisii, increasing land size beyond a certain point led to a decrease in productivity. The result was obtained by squaring the field size, whereby only collective action participants showed positive elasticity ( $p < 0.001$ ). The study attributes such differences to the variations in managerial ability between the two farmer categories, as well as the benefits the group members enjoy over the non-group members. As field size gets larger, it requires more managerial skills and mechanization that most of the smallholder farmers cannot afford. This prevents farmers from full utilization of the field capacity. Group participants enjoy extra human capital apart from family labour; furthermore, they have access to information on better management practices and innovative ideas (Mutonyi, 2019; Ombogoh et al., 2018).

Application of inorganic fertilizer also showed a positive significant effect on banana productivity among group members, however, the effect was only evident when the quantity of fertilizer applied surpass a certain level. High quantity of organic manure too had positive

significant coefficient for both the non-group and group members in Kisii and only group members in Nyamira County. The findings corroborate with previous findings by Ayinde et al. (2015) and Nsimbila (2021). Use of technology such as fertilizer application, application of organic manure provides the plants with the necessary micro and macronutrients, which boost their vegetative growth as well as fruit and seed formation (Muigai et al., 2021; Muthee et al., 2019). When the farmers get better information about the best ways to apply the technology, the farmer realizes better results through higher productivity. That explains why the association between fertilizer and manure application returned higher levels of association for the group participants in the study. There is consistent proof that group participation exposes its members to better extension advice on efficient use of technology, thus the expectation of higher association (Kurkenijad, 2021; Nsimbila, 2021). For the farmers in Nyamira County, field size and fertilizer interaction had negative impact on productivity levels among non-group members, whereas for group participants, it showed positive return. The outcome relates to the extension services that the farmers access in groups. Group members gain better access to information on the right technology in terms of quantity, quality and the type that enables them to make the right choices on the type of fertilizer to use during production depending on the edaphic factors.

### **5.3.2 The levels of technical efficiency among the banana producers**

In both counties, the technical efficiency levels were significantly higher for the group members. The results were consistent with the findings in previous surveys that established farmers who enjoy social capital to be less technically inefficient compared to those who pursue their production goals individually (Kurkenijad, 2021). Some of the reasons behind the higher technical efficiency among those farmers are, they are more likely to enjoy better access to production inputs, better access to skills that are prerequisite to efficient use of the inputs and new technologies in production (Endelaw et al., 2021; Songoro 2020). In addition, Coleman (2017), and Mutonyi (2019) affirm that farmers who participate in collective action are likely to be less inefficient technically, because they are more likely to enjoy better access to production information and other production-related support from such groups.

In other empirical studies, collective action enhances smallholder farmer's ability to strengthen their bargaining power, enhance their access to credit and innovations as well as associated farm

management skills, which could foster reduction in their inefficiency levels (Mwangi & Kariuki, 2014). The finding affirm the benefits farmers enjoy by participating in such collective action avenues as they also undertake the group underlying roles to help in achieving collective goals together as stipulated in the game theory (Ombogoh, 2019). Collective action is also likely to provide farmers with opportunity to receive mutual support that in times of need which eventually reduce technical inefficiency (Kurkenijad, 2021).

#### **5.4 Discussion of the sources of technical inefficiency by group participation**

From the results in Table 4.11, age of the farmer showed that older farmers were less technically inefficient than the younger ones for both farmer categories across the two counties. Increase in age, there lies an accumulation of experience overtime that equips one with better farming skills (Maganga, 2021; Tesfaw, 2021). Besides, age is a positive influencer for group participants in the study area, thus in addition to the accumulated expertise; the older farmers also embrace group participation. Consequently, they have better access to inputs, new farming technologies and innovations that improve their efficiency levels (Tefaw, 2021). The correlation between age and technical inefficiency was consistent with earlier findings, where older farmers were less technically inefficient (Fischer & Qaim, 2014; Khanal et al., 2021). By disregarding collective action, the majority of the younger farmers misses important innovations and information that could enable them improve their efficiency (Anang et al., 2018).

Gender of the farmers showed a significant effect in inefficiency levels among the group participants in both counties. The male farmers were more technically inefficient than their female counterparts were. The finding allude to the fact that banana production remains a female-dominated activity with very little male contribution (Njuguna et al., 2012). For that reason, female farmers are more motivated to seek efficient ways of producing the crop than male ones that explains the difference in inefficiency levels. The higher level of involvement of the women in producer groups also contributes to better productivity levels (Ngango & Kim, 2019).

The formal occupation significantly showed increase in inefficiency among non-group members, especially in Kisii County. On the contrary, informal occupation had a significant decrease in

inefficiency levels among the farmers in Kisii and Nyamira. The study can attribute the results to the fact that salaried employees spend most of their time in providing service to their employers. It leaves them with little or no time to spend in managing or monitoring the activities in their farms. A number of the farmers who are under formal employment who interviewed said that they delegate farming duties, while others engage either casual or salaried farm workers. The majority of such farmers spent very little time with farmworkers, thus no adequate monitoring of the farm operations. There are sufficient evidence from literature that relate such a scenario to cause principal-agent problem (Ombogoh, 2019). On the other hand, informal occupation enables a farmer to get time to monitor farm work as well as manage operations on the farm, thereby reducing inefficiency. Access to extension advice was a negative source of technical inefficiency among the group members in Nyamira County as was expected during the study. Extension services provides farmers with the appropriate knowledge, skills and other necessary information that foster productivity. Farmers who receive such kind of information and put into practice are likely to realize better productivity from efficient use of the resources at the farmers' disposal (Ngango & Kim, 2019).

## **CHAPTER SIX**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **6.1 Conclusions**

With the main aim of the study being, to determine the influence of collective action participation on technical efficiency of smallholder banana producers in Kisii and Nyamira Counties, Kenya, the study focused on two specific objectives to achieve the main aim. The study used a sample size of 113 farmers in Kisii and 147 farmers in Nyamira counties respectively to answer to its objectives. The first specific objective was to determine the determinants of group participation among smallholder banana farmers across the two counties. The study used logit model to achieve the first objective of the study. The study established that, the household head, age of the farmer, female gender and married farmers had higher probability of joining groups as a form of collective action. In addition, mobile ownership as a means of communication, informal employment, and poor road conditions as well as the need to have access to extension services were positive incentives towards group membership. The above factors answer the first research question that sought establish the determinants of group participation among the smallholder banana producers in the study area.

The second objective of the study was to determine the level of technical efficiency among group members and non-group member banana producers in Kisii and Nyamira counties. To achieve the objective, the study used maximum likelihood estimation model of the stochastic frontier. Using the model, the study responded to the second and the third research questions of the study. The study identified the levels of technical efficiency to be significantly higher among the group participants across the two study areas. The mean technical efficiency for non-group members in Kisii County was 0.85, while group members had a mean of 0.89. In the case of farmers in Nyamira County, non-group members had a mean efficiency level of 0.81, while the group members had a mean of 0.85. In relation to predicting the technical efficiency levels, the study identified the factors that influence banana productivity. Production factors such as the field size, fertilizer and manure application, fertilizer and field size interactions had positive influence on productivity for the group participants. Field size and manure application also had positive influence for non-group participants. In identifying the sources of technical inefficiency, age was found to affect technical inefficiency in a negative for both group and non-group members.

Female farmers were less technically inefficient among the group members. Informal occupation and access to extension information also reduced inefficiency among farmers, especially the group participants.

There was an established similarity between factors that influence collective action and those which affect technical inefficiency among farmers. Therefore, addressing various the socio-economic, physical and technical challenges would be very important in resolving the farmer inefficiency problems. The fact that the results of production frontier model revealed that most of the variations in banana productivity was due to random shocks for both farmer categories, it can be concluded that the higher efficiency levels of farmers in production groups was as a result of the role groups play in helping smallholder farmers to cope with or resolve the underlying challenges. Consequently, that would enable the group participants to improve their technical efficiency levels in banana production.

## **6.2 Recommendations**

From the results which were obtained, five recommendations are proposed.

- i. There should be more effective laid down framework on encouraging farmer group participation which should be more focussed on the male farmers. Majority of male farmers still do not embrace banana production as viable agribusiness as shown in the results. This calls for a campaign by the government horticultural department as well as the non-governmental development agencies to create awareness on the importance of banana to both male and female farmers.
- ii. The study also recommends that more extension service programs should be focussed on the younger farmers to help in improving their technical efficiency levels. The effectiveness of such initiative would be enhanced if the younger farmers are encouraged to join farmer groups. The results pointed out that young farmers are less efficient in production, they also do not like group participation, but it is within the groups where they can access extension services on better technology to use in the course of production, access to other production skills and production factors.

- iii. Measures need to be put in place to assist those farmers who still find it difficult to access and use improved varieties. One way of achieving this is to come up with proper producer subsidies to encourage most farmers embrace new farming technologies.
- iv. Type of occupation was found to be an influence on farmer's choice on collective action participation. In this regard, farmers whose main source of income was formal were less likely to be involved in group activities. This could be attributed to the time schedules of most of the group meetings which disadvantage such farmers. It is therefore recommended that a framework should be put in place which takes into account various socioeconomic issues of farmers so as to motivate participation.
- v. Finally, the results obtained from the study showed few contradictions with some previous literature which calls for further research to give more consistent findings and reliable conclusions.

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## APPENDICES

### APPENDIX A: Questionnaire

**Egerton University - Tegemeo Institute/MSU**  
**Tegemeo Agricultural Policy Research Analysis (TAPRA II)**  
**Rural Household Survey 2014**

“We are part of a team at Egerton University, who are studying aspects to do with agricultural development in the country. Your participation in answering these questions is very much appreciated. Your responses will be **COMPLETELY CONFIDENTIAL**. Your responses will be added to those of other households and analysed together. If you indicate your voluntary consent by participating in this interview, may we begin? If you have any questions or comments about this survey, you may contact the Director, Tegemeo Institute, Egerton University, P.O. Box 20498 (00200), Nairobi; **Tel: 0720 895454**; email: [egerton@tegemeo.org](mailto:egerton@tegemeo.org)”

Household Number **HHID:** \_\_\_\_\_ Date: (DD/MM/YY) **SURDATE:** \_\_\_\_\_

Household Name; \_\_\_\_\_ **HHNAME**

Respondent; \_\_\_\_\_ **MEM1:** \_\_\_\_\_

Respondent; \_\_\_\_\_ **MEM2:** \_\_\_\_\_

**(Enumerator Instruction:** Record the member number of the Respondent from the Demography Table on pages 19 through 21 after the survey is completed.)

#### **Identifying Variables:**

Supervisor: \_\_\_\_\_ **SNUM:** \_\_\_\_\_

Enumerator: \_\_\_\_\_ **ENUM:** \_\_\_\_\_

County : \_\_\_\_\_ **COUNT:** \_\_\_\_\_

Subcounty: \_\_\_\_\_ **SUBCOUNT:** \_\_\_\_\_

Ward \_\_\_\_\_

**WARD** \_\_\_\_\_

Location : \_\_\_\_\_

**LOC :** \_\_\_\_\_

Sub-location : \_\_\_\_\_

**SUBLOC:** \_\_\_\_\_

Village : \_\_\_\_\_

**VIL :** \_\_\_\_\_

CellphoneNumberCell : \_\_\_\_\_

GPS coordinates:(1=North 2=South): **NS:**\_\_\_\_\_ **HH1:** \_\_\_\_\_' \_\_\_\_\_(dd) **HH3:**Altitude **m.a.s.l** ( \_\_\_\_\_(M)

IF THE HOUSEHOLD IS **NOT ABLE TO PARTICIPATE** IN THE SURVEY, WHY NOT? **INTVIEW** \_\_\_\_\_

(1=head & spouse separated 2= refused 3= household members cannot be found 4 =family commitments; (burial, wedding, etc.) 5 =working outside area 6= other, specify\_\_\_\_\_)

**CROP INVENTORY AND CROP CODES:**

Did you produce bananas either in the **harvest of 2013 /2014?** (**Yes =1; No=0;** )

**Q1.0 LAND TENURE**

**Ask all the questions as applicable about the land parcel tenure statusof all the parcels accessed in 2013/14 cropping year**

*Land14.sav (Key Variables: hhid, pid)*

Parcel Name (Together with the respondent, give each parcel a name)	Parcel ID	Parcel Size in Acres
<b>pname</b>	<b>PID</b>	<b>pacres</b>
	<b>1</b>	
	<b>2</b>	
	<b>3</b>	
	<b>4</b>	
	<b>5</b>	



crop	pid	field	acres	system	landprep	lpcost	mem1	mem2	sdtype	sqt	sunlit	scost	ptrees	ft1	fq1	fu1	ft2	fq2	fu2	ft3	fq3	fu3	hvt	hunit	sale

<b>Unit codes:</b> 1=90 kg bag 11=50kg bag 2=kgs 3=litre 4=crates 5=numbers	6=bunches (bananas) 7=25kg bag 8=10kg Bag 9=gorogoro 10=tonnes 12=debe 13=grams	14=wheelbarrow 15=cart 16=canter 17=pickup 18=2kg packet(seed) 19=bale	<b>Fertilizer codes</b> 1 DAP 2 MAP 3 TSP 4 SSP 5 NPK (20:20:0) 6 NPK (17:17:0)	7 NPK (25:5:+5S) 8 NPK (23:23:23) 9 NPK (20:10:10) 10 NPK(23:23:0) 11 NPK(17:17:17) 12 NPK(18:14:12)	13 NPK(15:15:15) 14 NPK 14:14:20 15 CAN (26:0:0) 16 ASN (26:0:0) 17 UREA (46:0:0) 18 SA (21:0:0)	19 manure 20 foliar feed 21 magmax lime 22 DSP 23 mavuno-basal	25 rock-phosphate 26 mijingu 1100 27 gypsum lime 28 Blended fertilizer (specify) 29 other (specify)
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**Q2.3.** Did this household carry out any cropping activity during **SHORT CROP Season 2013/2014?** (1=Yes 0=No) **SHOTCROP**

**SHORT CROP 2013/2014** (Eastern Kenya refers to Jul-Sept 2013 harvest, Western, Coast, Central Nov 2013-Jan 2014, Rift Valley; planted in October rains)

*Crop14.sav*(Key variables: *hhid,harvest,field,crop*)**Harvest=2** (use units in 2.2)

Crop code	Parcel ID	Field No.	Acres	Main system of watering used 1=Rain fed 2=Irrigated(pumped) 3=irrigated (gravity) 4=other specify -	Main land prep type 0=none 1=manual 2=oxen 3=tractor	Hired land prep cost (Ksh)	Who is the person responsible for growing this <b>crop on this field?</b> <i>(If shared equally between two people, list both IDs)</i>		Planting /Seed Type 1=Purchase./New Hybrid 2=Retained Hybrid 3=OPV 4=local var. 5=local seedling/cuttings/split 6=improved seedling/cuttings/splits 7=hybrid & local var. 8=hybrid pur+retained	Quantity of seed used & cost, if purchased this season			Number of productive fruit trees	1 <sup>st</sup> Fertilizer used			2 <sup>nd</sup> Fertilizer used			3 <sup>rd</sup> Fertilizer used			Harvest -777=not yet harvested		Was this crop sold? 1=yes 2=No	
							Qty	Unit		Cost per unit	Type	Qty		Unit	Type	Qty	Unit	Type	Qty	Unit	Qty	Unit	Qty	Unit		
crop	pid	field	acres	system	landprep	lpcost	me m1	me m2	sdtype	sqt	sun it	scost	ptrees	ft1	fq1	fu1	ft2	fq2	fu2	ft3	fq3	fu3	hvt	hunit	sale	

**3.0) CREDIT** (*probe for all types of credit including credit in kind, e.g. farm inputs on credit*)

**Q3a.** Did any household member try to get any cash or in-kind credit during the 2013/14 cropping year? (1=Yes 2=No; →go to Q4)

CASHCRD\_\_\_\_\_

**Q3b.** Fill for all members of the household who tried to apply for credit (Cash or in-kind) in the last 12 months (May2013 to April2014)

*Finassets14.sav* (Key variables: *hhid; mem*)

Name and ID of person who applied for the credit	Person ID	Amount applied for (KES) <i>List each credit amount on a separate line.</i>	Form of credit applied for 1= cash 2= in-kind	Person or institution applied from? <i>Use codes below.</i>	Main Purpose for which credit was sought	Was the application successful? 1=Yes [skip to RESPONSES] 0=No	If credit denied, reason for denial 1=no security 2=outstanding loan 3=don't now 4=Failed to meet requirements	Amount Received	Total amount to repay including interest	Repayment period in months	Did you provide collateral? 1=Yes 0=No	If collateral type
NAME	MEM	CRAMNT	CRFORM	CRSORCE	CRPURP	SUCES	CRDENY	AMTREC	AMTREP	PERIOD	COLAT	COLTYP
<b>Source of credit codes</b>			4=commercial bank	8=MFI	12=KFA	<b>COLTYP</b>		6=Livestock				
1=Family			5=SACCOS	9=Money lender	13=Other Coop	1=Title deed		7=Logbook				
2=Friends			6=Group (Registered)	10=KTDA	14=Shylock	2=Shares		8=Produce deliveries				
3=employer			7=Group (Unregistered)	11=Coffee coop	15=village bank	3=Household Asset		9=Salary/Pension				
					16=Other, (Specify)	5=Business stock		10=Other specify_____				



23=NPK (18:14:12)	51=gunny bags					
24=NPK (15:15:15)	52=ridger cost					
58=NPK(25:5:0)	54=land					
25=Mavuno-basal	preparation					
26=Kero green	cost( <i>on credit</i>					
27=Rock phosphate	<i>only</i> )					

## GROUP PARTICIPATION

**Q5.0.** Does any member in this household participate in banana production group? **Grppart**.....(Yes=1; No=0)

List all the names and ID of members of the households who belong to any group and answer subsequent questions

*Grpmem14.sav* (Key variables: *hhid; mem; group*)

ID of household members who belong to a group.  <i>(May have multiple lines with the same ID number, if that person belongs to multiple groups.)</i>	Services offered within the group  1=Training and capacity building 2=Input acquisition and credit services 3=General welfare services	Gender composition in the group		Gender composition in the group's management committee		Position held in this <b>group</b>  1=chair 2=Vice chair 3=Secretary 4=Treasurer 5=Committee member 6=Ordinary member	Have you received any funds as a group in the last 5 years? (eg youth fund, women fund)	Amount received (KES.)
		No. of males	No. of females	No. of males	No. of females			

memid	serve1	Serve2	gmal	gfemale	cmale	cfemale	positn	fundrec	amtrec

**Q6.DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD MEMBERS (Adults and Children)**

(A household member to be listed is anyone who lived in the household for at least one full month during the last 12 months (July 2013-June2014).

For head and spouse, they are considered household members irrespective of the duration they were physically present at home).**Demog14.sav**

(Key variables: inform, mem) **Reference Period: May 2013 to April 2014**

ID	Name	In which year was [.....] born?	What is the sex of [.....]? 1=male 2=female	Relation-ship of [.....] of current head (See codes below)	Marital Status of [.....] (See codes below)	Is [.....] currently attending school? (For kids<3 yrs, skip TO DA07)  1 = Yes 2 = No	What is the highest level of education [.....] completed? (See codes below)	Is ...] currently considered a member of this household? 1=Yes →DA09 2=No	How many months in the period May 2013 to April 2014 has [.....] been living at home?	Did [.....] receive cash from informal /business activity? Include farm kibarua, dividends Between May 2013 & April 2014 1=Yes 2=No	Did [.....] receive cash or payment in kind from salaried employment, wage activities, remittances, or pensions between May 2013 & April 2014? 1=Yes 2=No
MEM	NAME	DA01	DA02	DA03	DA04	DA05	DA06	DA07	DA8	DA09	DA10

<b>Relation to head</b> 1=head 2=spouse 3=own child 4= step child 5= parent 6=	8= son/daughter in law 9=grandchild 10=other relative 11=unrelated /sister-in-law 13=parent-in-law	<b>Marital status</b> 1=single 2=monogamously married 3=polygamously married 4 = divorced 5 = widowed 6 = separated 7 = other, specify_____	<b>Education levels</b> -99=don't know -9=none 0=no formal education 1=std 1 2=std 2 3=std 3 4=std 4 5=std 5	9= form1 16= college 2 10 = form 2 17= college 3 11=form 3 18= college 4 12=form 4 19=univ 1	23=univ 5 & above 7= Other, specify_____															

**Q7. BUSINESS AND INFORMAL LABOUR ACTIVITIES**

We would like to know about all the off-farm income earning activities, including share dividends, your household was involved in, **except** *salaries employment pensions and remittances*. Please list the names of all persons from the demography Table who indicated they had engaged in a business or informal labour activity, then enter their corresponding person code From the list below, please list all the informal income earning activities for which this person had primary responsibility at any time during the past 12 months (**May 2013 to April 2014**) (include *jua kali & farm kibarua*). (**Probe for charcoal burning, fishing and own tree selling**)

*Business14.sav* (Key variables: *hhid, mem, activity*)

Pers on nam e	Perso n code mem	Activit y Code activity	Please <b>classify</b> each month's net earnings as:												Low earnings month		Average earnings month		High earnings month	
			0=None			1=Low			2=Average			3=High			l	g	a	g	h	g
			5/13	6/1	7/1	8/13	9/13	10/	11/	12/1	1/1	2/1	3/1	4/1	gros	lco	agros	acos	hgros	hcost
			may	jun	jul	aug	sept	oct	no	dec	jan	feb	mar	apr	ss	st	s	t	ss	



**Q8.SALARIED WAGE EMPLOYMENT/PERMANENT EMPLOYMENT ACTIVITIES**

We would now like to talk about all *salaried employment* that anyone in this household engaged in during the past 12 months from **May 2013 to April 2014** including **pensions and remittances**. For remittances remember to separate into local and from abroad, depending on source. Include only income remitted back to household.

*Salwg14.sav* (Key variables: *hhid, mem, activity*)

Person name <i>Please list the names of all persons from the demography Table who indicated they had engaged in salaried employment activities, then enter their corresponding person code</i>	Person code	From the list below, please list all the <b>salaried employment activities</b> in which this person was engaged at any time during the past 12 months	What is [...] current monthly wage? KES.	Did [...] earn this same monthly wage during all of the past 12 months? 1=Yes (->go to incuse) 2=No	If [.....] did <b>not</b> earn the <b>same</b> wage during <b>all</b> 12 months, please indicate the wage earned for <b>each</b> month individually (KES) <i>(Skip this section if person received the same monthly wage during the whole year)</i>												What was the Income used for? 1=Food 2=clothin 3=Health 4=Buying Durables 5=School fees 6=other specify
					5/13	6/13	7/13	8/13	9/13	10/13	11/13	12/13	1/14	2/14	3/14	4/14	
NAME	MEM	ACTIVITY	MNWAGE	SAME	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	incuse

**Employment Codes:**

- |                        |                |                |                 |              |                      |                 |                |
|------------------------|----------------|----------------|-----------------|--------------|----------------------|-----------------|----------------|
| 18 Accountant          | 2 Civil leader | 45 Driver      | 6 General farm  | 19 Manager   | 53 Plumber/battery   | 31 Secretary    | 15 Teacher     |
| 5 Administrator        | 20 Cleaner     | 4 Doctor       | 47 Hair dresser | 39 Mechanic  | 11 Policeman/woman   | 24 Shop         | 54 Technician  |
| 38 Banker/receptionist | 23 Clerk       | 40 Electrician | 7 House help    | 28 Messenger | 59 Postmaster        | 57 Soldier      | 26 Veterinary  |
| 50 Butcher             | 3 Committee    | 36 Engineer    | 8 Industrial    | 60 Miller    | <b>12 Remittance</b> | 62 Sports/coach | 16 Waiter/cook |

44 Cane cutter      35 Conductor      56 Equipment      33 Lab attendant      9 Nurse      **65 Remittance**      29 Subordinate      17 Watchman  
 1 Caretaker/groundsman      25 Construction      46 Extension      58 Lawyer      27 Pastor/religious      63 Research      32 Surveyor      43 Welding  
 55 Carpenter/mason      51 Cook/caterer      52 Fishing      21 Lecturer/tutor      10 Pension      22 Road constructor      41 Tailor      42 Other,  
 34 Chief      49 Craftsman/artisan      61 Forester      30 Lumber      64 Petrol seller      13 Sales person      14 Tea picker

**Q9. HOUSEHOLD ASSETS (PROMPT for each item as listed below)**

**At present**, how much/many of the following does this household **own** that are **usable/repairable**?

*Asset14.sav (Key Variables: hhid, asset)*

Agricultural asset		Quantity	Total Value ( <i>if given per unit value, sum them</i> )	Who owns these assets (use ID from demog)	Agricultural asset		Quantity	Total Value ( <i>if given per unit value, sum them</i> )
ASSET		QTY	TOTVAL	OWNSHP	ASSET		QTY	TOTVAL
31	houses				27	bicycle		
23	stores				34	motorcycle		
43	poultry houses				18	car		
44	piggery houses				19	truck		
29	zero-grazing units				17	tractor		
25	wheel barrow				16	trailer		
39	chaff cutter				13	ploughs for tractor		
28	radio				53	harrow/tiller		
36	TV				58	ridger/weeder		
40	solar panels				55	planter		
41	battery				47	boom sprayer		
46	land line				54	sheller		
71	phone (mobile)				26	combine harvester		
42	weighing				57	generator		
52	pestle & mortar				37	power saw		
22	water tanks				35	grinder		

30	beehive			38	jaggery unit		
45	water pump			59	cane crusher		
33	borehole			50	donkey		
49	Water pan			61	oxen		
60	well			14	animal traction		
21	irrigation			15	cart		
48	cattle dip			62	other (specify)-----		
20	spray pump			63	Hammer ( <i>posho</i> )		
51	water trough			64	Sewing/knitting		

## INFRASTRUCTURE

(Enumerator Instruction: Distance should be recorded in kilometers (Km))

### Q10. Distances from your homestead

- a) What is the distance from your homestead to the nearest **fertilizer seller**? **FERTSKM** \_\_\_\_\_
- b) How much does it cost to transport a 50 kG bag of fertilizer from the nearest seller to homestead? **FERTRANS** \_\_\_\_\_
- c) With what type of transport from seller to homestead?  
 (1=car,2=bus, 3=*matatu*, 4=bicycle, 5=ox-cart 6=other specify\_\_\_) **TRANTYPE** \_\_\_\_\_
- d) What is the distance from your homestead to **extension advice**? **DEXTN** \_\_\_\_\_
- e) What is the distance from your homestead to the nearest **market place** for **farm input**? **MKTKM** \_\_\_\_\_
- f) What is the distance from your homestead to a **motorable road**? **DMTROAD** \_\_\_\_\_
- g) What is the distance from your homestead to a **tarmac road**? **DTMROAD** \_\_\_\_\_

THANK YOU

## APPENDIX B: Published article

Appendix 1C: A Snapshot of the Abstract Page of the Published Paper

*Journal of Food Security*, 2020, Vol. 8, No. 3, 105-116  
Available online at <http://pubs.sciepub.com/jfs/8/3/4>  
Published by Science and Education Publishing  
DOI:10.12691/jfs-8-3-4



# Influence of Collective Action Participation on Technical Efficiency among Smallholder Producers: A Case of Banana Farmers in Kisii and Nyamira, Kenya

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**Abstract** The main aim of the paper is to analyse the influence of collective action participation defined as group participation on technical efficiency among smallholder banana producers in Kisii and Nyamira Counties, Kenya. Using stochastic frontier approach, the study evaluated how farmers in collective action differ from non-collective action participants in terms of technical efficiency levels of banana production as well as the factors responsible for inefficiencies among farmers. Logistic regression model is also used to determine the characteristics of group participation among the smallholder producers. The findings were based on cross-sectional data with a sample size of 260 smallholder banana producing households obtained through a multi-stage sampling technique. From the results obtained from logistic regression, salaried occupation had a significant adverse effect on group participation, while age, gender, education level, informal occupation, mobile phone ownership and access to extension advice had a significant positive impact. Besides, the stochastic production frontier model estimates showed that group members were more technically efficient than non-members at the 1% significance level. Field size, use of manure and inorganic fertilizer had a significant positive effect on productivity levels with high returns to scale exhibited among non-group members. Inefficiency levels were significantly affected by the age, gender and occupation of the household head. In conclusion, collective action helps farmers to address various production needs, thus making them more technically efficient.

**Keywords:** *stochastic frontier model, group participation, inefficiency levels*

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## APPENDIX C: Research permit

The data was collected by Tegemeo Institute of Agricultural Policy and Development. The institute has a charter that gives it authority to conduct surveys without obtaining the research permit. The author was an enumerator in the data collection exercise and later obtained an approval from the institute to use the data for academic purposes. The authorization is attached.

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**TEGEMEO INSTITUTE OF AGRICULTURAL  
POLICY AND DEVELOPMENT**

11<sup>th</sup> November 2021

### To Whom It May Concern:

Tegemeo Institute is a Policy Research Institute under the Division of Research & Extension of Egerton University. The Institute's mandate is to carry out policy research on issues related to agriculture and rural development. In pursuit of its mandate, the Institute collects data, which it analyses and generates evidence to inform policymakers and other stakeholders as to available policy options.

The Institute has collected data on a panel of rural households in Kenya over the last 13 years (1997, 2000, 2004, 2007 and 2010). In 2014, the Institute started a new panel dataset targeting 7,000 households. The household survey collected data on agricultural productivity (crops and livestock), input use and adoption, non-farm income-generating activities, and other crucial information to inform various government and donor interventions.

Mr Wilfred Omondi was one of our enumerators who was involved in data collection for the household survey. The survey was implemented between July and September 2014 attained a response rate of 93%, with 6512 households responding to the survey.

Subsequently, My Omondi requested to use the data to analyse for his Masters Thesis titled "Influence of Collective Action Participation on Technical Efficiency Among Smallholder Banana Producers in Kisii and Nyamira Counties, Kenya".

Enclosed, please find the contract for Mr Omondi issued during data collection and Mr Omondi's approval to use the 2014 survey household data for his thesis.

**Dr Timothy Njagi, PhD**  
Development Economist/Research Fellow,  
Tegemeo Institute, Egerton University



**APPENDIX D: Data analysis results**

**RESULTS FOR NYAMIRA**

```
logit grppart hsize hhd_pos age gender marital educ_level sal bus
dummratio phonown ///
> totval_ast mnwage mktkm dtmroad ctmroad cramtrec recadv facres,
cformat(%9.3fc) // coefficients
```

```
Iteration 0: log likelihood = -91.342642
Iteration 1: log likelihood = -37.522536
Iteration 2: log likelihood = -30.062818
Iteration 3: log likelihood = -27.206962
Iteration 4: log likelihood = -26.912996
Iteration 5: log likelihood = -26.908818
Iteration 6: log likelihood = -26.908816
```

```
Logistic regression                                Number of obs    =
145                                                  LR chi2(18)      =
128.87                                              Prob > chi2      =
0.0000                                              Pseudo R2       =
Log likelihood = -26.908816
0.7054
```

```
-----
-----
      grppart |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
-----+-----
      hsize |      0.018    0.141     0.13   0.900    -0.260
0.295
      hhd_pos |     -2.625    1.132    -2.32   0.020    -4.843
0.407
           age |      0.045    0.035     1.28   0.200    -0.024
0.115
           gender |      3.610    1.149     3.14   0.002     1.358
5.862
           marital |      0.301    1.594     0.19   0.850    -2.822
3.425
```

educ_level	0.098	0.131	0.75	0.451	-0.158	
0.354						
sal	-5.184	2.018	-2.57	0.010	-9.140	-
1.229						
bus	6.800	2.895	2.35	0.019	1.125	
12.475						
dummradio	-1.945	0.950	-2.05	0.041	-3.806	-
0.083						
phonown	3.611	1.627	2.22	0.026	0.422	
6.799						
totval_ast	0.000	0.000	0.12	0.904	-0.000	
0.000						
mnwage	-0.000	0.000	-0.63	0.531	-0.000	
0.000						
mktkm	0.453	0.278	1.63	0.103	-0.091	
0.997						
dtmroad	0.010	0.104	0.10	0.924	-0.194	
0.214						
ctmroad	-1.047	0.674	-1.55	0.120	-2.368	
0.274						
cramtrec	0.000	0.000	1.51	0.131	-0.000	
0.000						
recadv	4.591	1.220	3.76	0.000	2.200	
6.982						
facres	2.561	1.723	1.49	0.137	-0.815	
5.938						
_cons	-5.165	3.630	-1.42	0.155	-12.279	
1.949						

-----  
-----

Note: 0 failures and 2 successes completely determined.

```
. logit grppart hhsz hhd_pos age gender marital educ_level sal bus
dummradio phonown ///
> totval_ast mnwage mktkm dtmroad ctmroad cramtrec recadv facres, or //
odds ratio
```

```
Iteration 0: log likelihood = -91.342642
Iteration 1: log likelihood = -37.522536
Iteration 2: log likelihood = -30.062818
Iteration 3: log likelihood = -27.206962
Iteration 4: log likelihood = -26.912996
Iteration 5: log likelihood = -26.908818
```



dtmroad		1.009967	.1049998	0.10	0.924	.8237834
1.238229						
ctmroad		.3509894	.2365841	-1.55	0.120	.0936575
1.315363						
cramtrec		1.000108	.0000717	1.51	0.131	.9999677
1.000249						
recadv		9.46711	120.2866	3.76	0.000	9.023394
1077.288						
facres		2.87141	22.31318	1.49	0.137	.4424201
379.1398						
_cons		.0087107	.0207282	-1.42	0.155	4.65e-06
7.019338						

-----  
 ---

Note: \_cons estimates baseline odds.  
 Note: 0 failures and 2 successes completely determined.

.  
 .  
 . mfx // marginal effect after logit

Marginal effects after logit  
 y = Pr(grppart) (predict)  
 = .97571385

variable		dy/dx	Std. Err.	z	P> z	[ 95% C.I.
]	X					]
hsize		.000422	.00328	0.13	0.898	-.006
.006844		6.8069				
hhd_pos		-.0621973	.06058	-1.03	0.305	-.180941
.056547		1.47586				
age		.0010738	.00129	0.83	0.405	-.001453
.0036		47.6276				
gender*		.1556854	.11689	1.33	0.183	-.073411
.384782		.565517				
marital*		.0080999	.04974	0.16	0.871	-.089392
.105592		.931034				
educ_1~1		.0023323	.00395	0.59	0.555	-.005415
.01008		10.6828				

sal*	-.6427212	.34646	-1.86	0.064	-1.32176
.03632	.165517				
bus*	.1235265	.07532	1.64	0.101	-.024096
.271149	.255172				
dummrav~o*	-.0597061	.05173	-1.15	0.248	-.161104
.041691	.427586				
phonown*	.3332345	.32086	1.04	0.299	-.295641
.96211	.848276				
totval~t	6.15e-08	.00000	0.12	0.903	-9.3e-07
1.1e-06	13136.7				
mnwage	-2.13e-06	.00000	-0.55	0.583	-9.8e-06
5.5e-06	3142.07				
mktkm	.0107332	.00973	1.10	0.270	-.008338
.029804	3.24379				
dtmroad	.000235	.00251	0.09	0.926	-.004693
.005163	3.93578				
ctmroad	-.02481	.02364	-1.05	0.294	-.071135
.021515	1.36552				
cramtrec	2.57e-06	.00000	1.00	0.318	-2.5e-06
7.6e-06	6270				
recadv*	.2135785	.12859	1.66	0.097	-.038444
.465601	.524138				
facres	.0606912	.05694	1.07	0.286	-.050905
.172288	.412405				

-----  
 -----  
 (\*) dy/dx is for discrete change of dummy variable from 0 to 1

. margins

Predictive margins  
 = 145

Number of obs

Model VCE : OIM

Expression : Pr(grppart), predict()

```

-----
-----
              |              Delta-method
              |              Margin   Std. Err.      z    P>|z|    [95%
Conf. Interval]
-----+-----
              |
      _cons |   .6758621   .0200404   33.72   0.000
      .6365836   .7151405
-----
-----

```

**Stochastic model for Nyamira county**

```

by grppart, sort : frontier log_Havest log_fieldsize
log_fertqty log_manuqty logfieldsq log_fertsq log_manuresq fildfertint
fildmanu fertma
    > nu, distribution(tnormal) cm(hhsize age educ dugender dumart
sal bus recadv mnwage totval_ast cramtrec) iterate(10)

```

```

-----
-> grppart = 0
note: fertmanu omitted because of collinearity

```

```

Iteration 0: log likelihood = -88.85686
Iteration 1: log likelihood = -81.74614
Iteration 2: log likelihood = -41.52702
Iteration 3: log likelihood = -30.80751
Iteration 4: log likelihood = -27.56832
Iteration 5: log likelihood = -27.551812
Iteration 6: log likelihood = -27.86558

```

```

Stoc. frontier normal/truncated-normal model      Number of obs   =
49
                                                    Wald chi2(8)     =
152.13
Log likelihood = -27.57102                          Prob > chi2      =
0.0000

```

```

-----
-----
Interval]      log_Havest |      Coef.   Std. Err.      z    P>|z|      [95% Conf.
-----+-----
-----
log_Havest    |
log_fieldsize |      0.651907   .0784089     6.96   0.041     .9930326     1.770781
log_fertqty   |      1.186695   .8338039     1.64   0.102     -.233935     2.603324
log_manuqty   |     -.3375422   .2480827    -1.70   0.088     -.7257772     .0506927
logfieldsq    |     -.3236226   .062503     -1.58   0.115     -.2211263     .0238811
log_fertsq    |      .0087682   .104102      0.03   0.979     -.63038      .6479165
log_manuresq  |      .1368034   .0751012     2.76   0.116     .0280064     .1656004
fildfertint   |     -.0425732   .1629239    -3.29   0.024     -.8546981    -.2160483
fildmanu      |     -.0532615   .0388346    -1.37   0.170     -.1293759     .0228528
fertmanu      |      .0152473   .0261241    -2.14   0.145     -.3175902     .1042233
_cons        |      3.700889   .3635113    17.47   0.002     5.63642     7.061358
-----+-----
mu
hhsz         |     -.7386305   .4559432    -1.38   0.167     -.0003153     .0000544
age          |     -.2350542   .024442      3.39   0.000     .006348     .0237605
educ         |     -.2429565   .0017108      0.34   0.734     -.0141164     .0200294
dugender     |      .8295689   .0113505    -0.56   0.573     -.3566108     .197473
marital      |     -.323442    .1374124     1.38   0.167     -.1602761     .9271605
sal          |      .6797611   .2840714     1.88   0.060     -.0122133     .5917355
bus          |      .5395419   .1540539    -1.88   0.060     -.5914821     .0123982
recadv       |     -.165937    .1436278     0.11   0.012     -.2655682     .2974423
mnwage       |      1.79e-06   4.78e-06     0.38   0.707     -7.57e-06     .0000112
totval_ast   |      6.75e-07   1.87e-06     0.36   0.718     -2.99e-06     4.34e-06
cramtrec     |      7.30e-07   5.00e-07     1.46   0.144     -2.49e-07     1.71e-06
_cons        |     -.4417846   .5467618    -0.55   0.580     -1.369498     .7659289
-----+-----
/lnsigma2    |     -1.153175   .1432727    -8.05   0.000     -1.433984    -.8723655
/ilgtgamma   |     -6.117658   .          .          .          .          .
-----+-----
sigma2       |      .3156331   .0452216          .          .          .          .
gamma        |      .0021988   .          .          .          .          .
sigma_u2     |      .000694    .          .          .          .          .
sigma_v2     |      .3149391   .          .          .          .          .
-----+-----

```

-> grppart = 1

```

Iteration 0:  log likelihood = -110.2084
Iteration 1:  log likelihood = -89.75176
Iteration 2:  log likelihood = -71.47461
Iteration 3:  log likelihood = -51.27953
Iteration 4:  log likelihood = -55.24399
Iteration 5:  log likelihood = -55.34306

```

Iteration 6: log likelihood = -55.28048

Stoc. frontier normal/truncated-normal model      Number of obs =      98  
Wald chi2(9) =      75.20  
Log likelihood = -55.1007      Prob > chi2 =      0.0000

log_Havest	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
log_Havest						
log_fieldsize	.4794529	.182814	-1.16	0.006	-.6171611	.1582554
log_fertqty	.1047769	.0901121	-1.30	0.127	-.6431094	.1295557
log_manuqty	-.0162436	.2592034	-0.10	0.924	-.3478763	.315389
logfieldsq	.8457215	.0431834	4.50	0.000	.1273638	.3240791
log_fertsq	.320883	.0750537	1.89	0.009	-.00466	.246426
log_manuresq	1.4169722	.0604139	0.43	0.027	-.0425419	.0664864
fildfertint	.6354273	.230968	1.84	0.036	-.011743	.3625975
fildmanu	-.013093	.2326988	-0.67	0.503	-.0709887	.0348026
fertmanu	.0315214	.0264864	0.13	0.894	-.048391	.0554338
_cons	4.024177	.169734	36.35	0.000	7.213106	8.035248
mu						
hysize	.2167305	.0655140	-0.22	0.828	-.0003061	.0002451
age	-.0150008	.0125141	0.61	0.000	-.0155664	.0295681
educ	.5441628	.071212	0.13	0.894	-.0570116	.0653372
dugender	-.1143886	.4081019	-0.00	0.004	-.5464582	.5436811
dumart	.0401742	.2570601	0.00	1.000	-1.032845	1.033193
sal	-.4814937	.0432101	0.07	0.006	-0.421032	.310733
bus	-.1806613	.0094709	0.07	0.036	-.0179015	.019224
recadv	.0010272	.	.	.	.	.
mnwage	-.0000411	.000038	-1.08	0.279	-.0001155	.0000333
totval_ast	-6.27e-07	1.26e-06	-0.50	0.619	-3.10e-06	1.84e-06
cramtrec	-2.51e-06	3.77e-06	-0.67	0.506	-9.90e-06	4.88e-06
_cons	.2714104	.6214315	0.00	1.000	-1.399623	1.400444
/lnsigma2	-.447677	.1115038	-4.01	0.000	-.6662204	-.2291335
/ilgtgamma	-4.661072	.	.	.	.	.
sigma2	.0691111	.0712633			.5136463	.7952224
gamma	.0693677	.			.	.
sigma_u2	.005987	.			.	.
sigma_v2	.6331241	.			.	.

**1. RESULTS FOR KISII**

```
. logit grppart hysize hhd_pos age gender marital educ_level sal bus
dumradio phonown ///
```

```
> totval_ast mnwage mktkm dtmroad ctmroad cramtrec recadv facres,
cformat(%9.3fc) // coefficients
```

```
note: recadv != 1 predicts failure perfectly
      recadv dropped and 5 obs not used
```

```
Iteration 0: log likelihood = -73.670336
Iteration 1: log likelihood = -51.681378
Iteration 2: log likelihood = -51.530866
Iteration 3: log likelihood = -51.529978
Iteration 4: log likelihood = -51.529978
```

```
Logistic regression                                Number of obs    =
108                                                  LR chi2(17)      =
44.28                                               Prob > chi2      =
0.0003                                             Pseudo R2       =
Log likelihood = -51.529978
0.3005
```

```
-----
-----
      grppart |      Coef.   Std. Err.      z    P>|z|     [95% Conf.
Interval]
-----+-----
-----
      hhsz     |      0.062    0.084     0.74   0.460    -0.103
0.227
      hhd_pos  |     -0.194    0.504    -0.38   0.700    -1.182
0.794
      age      |      0.039    0.021     1.84   0.066    -0.003
0.080
      gender   |      0.883    0.571     1.55   0.122    -0.235
2.002
      marital  |      0.226    1.277     0.18   0.860    -2.277
2.729
      educ_level |      0.000    0.074     0.00   0.996    -0.145
0.145
      sal      |     -1.949    0.766    -2.54   0.011    -3.450
-0.448
      bus     |      0.414    0.716     0.58   0.563    -0.989
1.818
```

dummradio	-0.240	0.549	-0.44	0.663	-1.316
0.837					
phonown	2.438	0.753	3.24	0.001	0.962
3.913					
totval_ast	-0.000	0.000	-0.04	0.969	-0.000
0.000					
mnwage	0.000	0.000	0.37	0.713	-0.000
0.000					
mktkm	0.025	0.053	0.47	0.639	-0.080
0.130					
dtmroad	-0.001	0.026	-0.02	0.982	-0.052
0.051					
ctmroad	0.011	0.286	0.04	0.969	-0.549
0.571					
cramtrec	0.000	0.000	0.00	0.999	-0.000
0.000					
recadv	0.000	(omitted)			
facres	-0.545	0.778	-0.70	0.484	-2.070
0.980					
_cons	-3.915	2.191	-1.79	0.074	-8.209
0.379					

-----  
-----

. use kisii\_data.dta, clear

```
Iteration 0: log likelihood = -73.670336
Iteration 1: log likelihood = -51.681378
Iteration 2: log likelihood = -51.530866
Iteration 3: log likelihood = -51.529978
Iteration 4: log likelihood = -51.529978
```

Logistic regression  
108

44.28

0.0003

Log likelihood = -51.529978  
0.3005

Number of obs =

LR chi2(17) =

Prob > chi2 =

Pseudo R2 =

-----  
-

grppart	Odds Ratio	Std. Err.	z	P> z	[95% Conf. Interval]
hhsz	1.064114	.0895667	0.74	0.460	.9022821 1.254972
hhd_pos	.8236823	.4151514	-0.38	0.700	.3067172 2.211981
age	1.039464	.0218923	1.84	0.066	.9974291 1.08327
gender	2.418635	1.380136	1.55	0.122	.7904108 7.400958
marital	1.253445	1.600721	0.18	0.860	.1025822 15.31575
educ_level	1.000369	.0740092	0.00	0.996	.8653403 1.156469
sal	.1424223	.1090858	-2.54	0.011	.0317406 .6390585
bus	1.513464	1.083539	0.58	0.563	.3720221 6.15709
dumradio	.7869869	.4321851	-0.44	0.663	.2682366 2.308963
phonown	11.44578	8.615182	3.24	0.001	2.617886 50.04267
totval_ast	.9999994	.0000147	-0.04	0.969	.9999706 1.000028
mnwage	1.000035	.0000957	0.37	0.713	.9998477 1.000223
mktkm	1.025398	.0548432	0.47	0.639	.9233497 1.138725
dtmroad	.9993975	.0263915	-0.02	0.982	.9489869 1.052486
ctmroad	1.011122	.2888037	0.04	0.969	.5776667 1.769822
cramtrec	1	.0000204	0.00	0.999	.99996 1.00004
recadv	1	(omitted)			
facres	.5798025	.4510603	-0.70	0.484	.126207 2.663647
_cons	.0199437	.043696	-1.79	0.074	.0002722 1.461376

Note: \_cons estimates baseline odds.

```
. logit grppart hhsz hhd_pos age gender marital educ_level sal bus  
dumradio phonown ///  
> totval_ast mnwage mktkm dtmroad ctroad cramtrec recadv facres, or // odds  
ratio
```

note: recadv != 1 predicts failure perfectly  
recadv dropped and 5 obs not used

```
Iteration 0: log likelihood = -73.670336  
Iteration 1: log likelihood = -51.681378  
Iteration 2: log likelihood = -51.530866  
Iteration 3: log likelihood = -51.529978  
Iteration 4: log likelihood = -51.529978
```

```
Logistic regression                                Number of obs    =  
108                                                LR chi2(17)      =  
44.28                                             Prob > chi2      =  
0.0003                                           Pseudo R2       =  
Log likelihood = -51.529978  
0.3005
```

```
-----  
-  
      grppart | Odds Ratio   Std. Err.      z    P>|z|     [95% Conf.  
Interval]  
-----+-----  
-  
      hhsz |   1.064114   .0895667     0.74   0.460     .9022821  
1.254972  
      hhd_pos |   .8236823   .4151514    -0.38   0.700     .3067172  
2.211981  
      age |   1.039464   .0218923     1.84   0.066     .9974291  
1.08327  
      gender |   2.418635   1.380136     1.55   0.122     .7904108  
7.400958  
      marital |   1.253445   1.600721     0.18   0.860     .1025822  
15.31575  
      educ_level |   1.000369   .0740092     0.00   0.996     .8653403  
1.156469
```

```

        sal | .1424223 .1090858 -2.54 0.011 .0317406
.6390585
        bus | 1.513464 1.083539 0.58 0.563 .3720221
6.15709
        dummradio | .7869869 .4321851 -0.44 0.663 .2682366
2.308963
        phonown | 11.44578 8.615182 3.24 0.001 2.617886
50.04267
        totval_ast | .9999994 .0000147 -0.04 0.969 .9999706
1.000028
        mnwage | 1.000035 .0000957 0.37 0.713 .9998477
1.000223
        mktkm | 1.025398 .0548432 0.47 0.639 .9233497
1.138725
        dtmroad | .9993975 .0263915 -0.02 0.982 .9489869
1.052486
        ctmroad | 1.011122 .2888037 0.04 0.969 .5776667
1.769822
        cramtrec | 1 .0000204 0.00 0.999 .99996
1.00004
        recadv | 1 (omitted)
        facres | .5798025 .4510603 -0.70 0.484 .126207
2.663647
        _cons | .0199437 .043696 -1.79 0.074 .0002722
1.461376

```

-----  
-  
Note: \_cons estimates baseline odds.

. mfx //marginal effect after logit

Marginal effects after logit  
y = Pr(grppart) (predict)  
= .56139694

```

-----
-
variable |      dy/dx   Std. Err.    z    P>|z|   [   95% C.I.   ]    X
-----+-----
-
    hhsize | .0153014    .02076    0.74   0.461   -.025391   .055993
5.72222

```

hhd_pos	-.0477614	.12416	-0.38	0.700	-.29111	.195587
1.55556						
age	.0095303	.00518	1.84	0.066	-.000621	.019682
47.2778						
gender*	.2147431	.13506	1.59	0.112	-.049979	.479465
.527778						
marital*	.0560962	.3189	0.18	0.860	-.568932	.681125
.925926						
educ_l~1	.0000909	.01822	0.00	0.996	-.035613	.035795
10.0648						
sal*	-.4389359	.13316	-3.30	0.001	-.699923	-.177948
.175926						
bus*	.0994652	.16603	0.60	0.549	-.225957	.424887
.157407						
dummr~o*	-.0590243	.13523	-0.44	0.662	-.324071	.206022
.435185						
phonown*	.5225162	.1097	4.76	0.000	.307508	.737524
.796296						
totval~t	-1.39e-07	.00000	-0.04	0.969	-7.2e-06	6.9e-06
11167.1						
mnwage	8.65e-06	.00002	0.37	0.713	-.000038	.000055
2951.3						
mktkm	.0061757	.01314	0.47	0.638	-.01958	.031931
5.71296						
dtmroad	-.0001484	.0065	-0.02	0.982	-.012893	.012596
9.16389						
ctmroad	.0027234	.07033	0.04	0.969	-.135121	.140568
1.67593						
cramtrec	6.17e-09	.00001	0.00	0.999	-9.8e-06	9.9e-06
8100.93						
facres	-.1342123	.19153	-0.70	0.483	-.509604	.241179
.392941						

-----  
-

(\*) dy/dx is for discrete change of dummy variable from 0 to 1