

**FARMERS ADOPTION OF IMPROVED BEAN VARIETIES IN MBEYA RURAL
DISTRICT, TANZANIA: SOCIAL CONSEQUENCE AND FINANCIAL
BENEFITS**



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ABSTRACT

Many farmers in developing countries are still highly reluctant in adopting new improved technologies. Mbeya region being one among the high producers of common beans in Tanzania, beans farmers adoption rates of improved varieties as one of the necessary technologies in production is still low. This study aimed at determining the adoption rate and assessing the profitability of the improved bean seeds used by farmers in Mbeya rural district. Specifically, the study intended to determine the adoption rate of beans farmers, its determinants and compare the profitability between adopters and non-adopters. A multistage sampling technique was used to obtain the respondents employed in the study. Data was collected from a random sample of 210 farmers from three villages in Mbeya rural district through structured questionnaires and key informant interviews. The results suggest a low rate of adoption that accounted for 31% of all the respondents. The Heckman model was used to identify factors affecting the adoption decision and intensity whereby farm size, seed price, education, extension services and off-farm income were the significant factors that influenced the adoption decision and intensity. The Gross margin analysis was used to compare the profit margins of adopters and non-adopters and it was observed that adopters obtained higher profit margins and costs compared to the non-adopters. From the study it is concluded that adoption of improved bean varieties in Mbeya rural district is still low attributed by the discussed socio-economic factors. Therefore, for any change in the bean sub-sector to be realized, careful consideration should be made in terms of improving rural education, extension services and accessibility to agricultural inputs provided that careful analysis will be done to ensure that benefits accrued will warrant the efforts.

DECLARARTION

I, Thedy Gerald Kimbi, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.



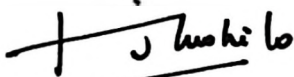
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DEDICATION

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LIST OF ABBREVIATIONS AND ACRONYMS

ADP	Agriculture Development Programme
AERC	African Economic Research Consortium
ARI	Agricultural Research Institute
CARITAS	Churches Around Richmond Involved To Assure Shelter
CCAFS	Climate Change Agriculture and Food Security
CIAT	Central International of Agricultural Tropical
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GM	Gross Margin
ha	Hectares
IITA	International Institute of Tropical Agriculture
MAFC	Ministry of Agriculture Food Security and Cooperatives
MT	Metric Tonnes
NARS	National Agricultural Research Systems
NBRP	National Bean Research Programme
NBS	National Bureau of Statistics of Tanzania
OLS	Ordinary Least Square
PABRA	Pan Africa Bean Research Alliance
pp	Page
SUA	Sokoine University of Agriculture
TARI	Tengeru Agricultural Research Institute
TR	Total Revenue
TVC	Total Variable Cost
VIF	Variance Inflation Factor

B	Beta
ε	Error term
δ	Delta
λ	Inverse Mills Ratio

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Common bean (*Phaseolus vulgaris*) is one among the important crops in the world whereby its production is also among important activities in Sub-Saharan countries for food and income generation within households. According to Larochelle *et al.* (2016), beans production is dominated in the central, eastern and southern Africa. In Eastern Africa the total production of beans is about 62% among the Sub-Saharan countries of which Tanzania is the leading producer in these countries (Fivawo and Msolla, 2011).

According to FAOSTAT (2016) common beans production in the country has increased to 1 158 039 Metric Tonnes (MT). Tanzania ranks the 5th position as the leading producer of beans in Africa as small holder farmers produce over 70% of the national bean production in the country (Binagwa *et al.*, 2014). According to Ronner and Giller (2013), beans production in Tanzania is dominated in the Northern, Great Lake and the Southern highlands by small holder and medium farmers whereby most of these farmers live in rural areas and are poor. The agricultural production system practiced by small holder farmers over a number of years in developing countries is mainly traditional and rain fed (Legese, 2004).

Common beans production plays a principal role to both large and smallholder farmers as a source of income and home consumption due to its dietary nutritional requirements, which is important to the human body (Arulbalachandran and Mullainathan, 2009). In addition to this beans production is important since it contributes to soil fertility improvement as well as providing fodder for livestock (Asfaw and Blair, 2014).

According to Binagwa *et al.* (2016) Tanzania exports common beans to more than ten countries including Uganda, Rwanda, Zambia, South Africa, Malawi, Zimbabwe, Democratic Republic of Congo (DRC) and India. The total export by the year 2016 was 97936 MT (FAOSTAT, 2016). Tanzania exports of pulses have grown faster over a number of years and within the last five years, the exportation growth has increased to 18% annually with the export of common beans contributing to 62% per annum (URT, 2016).

Due to the importance of the bean sector as the major source of income to farmers in the country, it is very important to encourage farmers to use and follow recommended agricultural practices so as to improve yields and profitability (Samboko, 2011). Despite the benefits of this crop, its production is constrained by different environmental factors especially pests and diseases, drought, excessive rainfall and low soil fertility (Siri *et al.*, 2016). Through research programmes in the country, problems of low production and low adoption of improved technologies by farmers are spotted in many areas. Therefore there is a need of deep studies so as to address unsolved problems in order to improve these technologies or the adoption rate of these technologies in beans production in the country (Ayalew, 2011).

Since the 1980s different international collaborative programs have been trying to conduct different research works on improved bean seeds production and dissemination as one among other improved technologies. The aim was to ensure global food security and help farmers to attain satisfying incomes (Rubyogo *et al.*, 2011). Some of these institutions include the Centro International de Agricultural Tropical (CIAT) from Columbia, National Bean Research Programme (NBRP), Pan Africa Bean Research

Alliance (PABRA), National Agricultural Research Systems (NARS), the One Acre Fund and the International Tropical Agriculture (IITA).

Through different programmes and projects many improved beans varieties that are highly resistant to drought and diseases have been released and disseminated to farmers (Rubyogo *et al.*, 2011). Between 2001 and 2015 a total of 34 improved varieties have been released and classified as potentially high yielding improved varieties. Some of these introduced varieties include Kablanketi, Urafiki, Selian, Uyole, Bilfa 16, NRI, CAL, Njano, Kabanima, Roba, Wanja and Soya (PABRA Database, 2015).

Integration of the improved varieties have been promising, but still there are low rates of improvements noted in beans production and its profitability since many farmers are still reluctant in adopting the improved varieties that result to lower yields (Letaa, 2015). Moreover, even the adopters of these varieties still face challenges of low yields (Larochelle, 2016). With the introduction of these different improved bean varieties in the country, adoption studies become very necessary so as to see the value of different agricultural investments made on the supply and use of these varieties (Reyes, 2012).

1.2 Statement of the Problem

Seventy percent (70%) of the world population lives in rural areas and rely heavily on agricultural production as the main source of food and employment, whereas the rural population in Tanzania was reported at 67% (World Bank, 2016). Currently, smallholder farms in East Africa account for about 75% of agricultural outputs, with average farm sizes of 2.5 hectares using traditional technologies and producing mainly for home consumption (Kinuthia *et al.*, 2017). Farmers in these developing countries have been struggling in different ways to increase food production and improve their income.

Due to low productivity facing the agricultural sector in most of developing countries, Governments and international research institutes have been trying on ways on how to innovate and disseminate different technologies to boost the sector's productivity. In the country, low productivity in the common bean sub-sector is widespread and is mainly caused by unfavorable factors that are pests and diseases, drought, low soil fertility and low adoption of the new and improved technologies (CCAFS, 2015). Until recently, there is a wide range of agricultural technologies that have been introduced and used by farmers. These include mechanization, irrigation equipments and improved agrochemicals (URT, 2015). Apart from these technologies used, improved seed varieties is also noted to have an important impact in increasing agricultural yields and profitability (Antolini, 2015).

Despite different efforts and achievements by breeding works in Tanzania whereby a total of 34 improved varieties have been introduced between 2001 and 2015, many common beans farmers are not adopting these improved varieties (PABRA Database, 2015). The average yield of common beans in Tanzania was 1035.4 kg/ha which was lower than that found in developed countries (FAOSTAT, 2016). This lower yield is contributed by the use of unimproved varieties that most of these farmers use in Tanzania. The farmers' adoption rate of improved bean varieties is still low and the reasons to this could probably be low education, low income, poor extension services, low availability of labour, lack of access to information and accessibility to markets. However, it is not known whether these factors or some of these factors hold for the case of beans farmers in Mbeya rural district.

There have been few studies conducted to determine the rate of adoption and factors influencing the adoption of improved bean varieties in the study area. According to Letaa

et al. (2015) on adoption of improved bean seeds in the Southern highland regions in Tanzania. adoption increased by 7.23 % from 23.34% in 2012 to 30.57% in 2013 which was still low. However there have been also very limited empirical information on factors influencing the intensity or extent of use of these improved varieties, example a study done by Letaa *et al.* (2015), assessed only the determinants of adoption decision of these farmers and not the extent of use of these improved varieties. Thus, the present study intends to fill this knowledge gap as both the adoption decision and the intensity of use of these improved seeds by beans farmers was assessed in Mbeya rural district.

Moreover, little is known about the profitability of improved beans varieties in the study area and profitability differences between improved and local seeds users. Some studies have indicated that apart from farmers using local varieties to obtain lower yields and profits, also some of the farmers who used improved varieties obtained low profits too. According to Shalma (2014) some of the beans farmers' experienced low profitability despite the improved seeds used whereby it was noted that improved seeds only was not a sufficient condition for high profitability.

1.3 Justification of the Study

This study aimed to contribute in helping different stakeholders in the bean sub-sector to improve the understanding on the actual current rate of adoption, profitability of improved varieties and determinants of the adoption decision and intensity of these improved varieties by farmers. This will help these stakeholders to make well informed and optimal decisions which will improve the performance of the sub-sector.

1.4 Objectives of the Study

1.4.1 Overall objective

The general objective of this study is the determination of the rate of adoption, its determinants and influence of improved bean varieties on profitability in Mbeya rural district.

1.4.2 Specific objectives

Specifically, the study intends to:

- i. Determine the rate of adoption of improved bean varieties among beans farmers in Mbeya rural district.
- ii. Determine the determinants of adoption decision and intensity of improved bean varieties.
- iii. Compare the profit margins of common beans production between adopters and non-adopters of improved bean varieties.

1.5 Hypotheses

- i. HO: Factors such as age, gender, education, experience, off-farm income, seeds prices, credit, extension services and farm size have no influence on adoption decision and intensity of adoption of improved bean varieties.
- ii. HO: There is no significant difference in farmers' profit margins between adopters and non-adopters of improved bean varieties.

1.6 Research Question

- i. What proportion of farmers have adopted improved bean varieties in Mbeya rural district?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Terms

2.1.1 Adoption concept and the improved seeds

According to Mustapha *et al.* (2012), adoption of any technology refers to the systematic application of introduced new resources to solutions of problems through control over nature and human processes. Dimara (2003) defined adoption of any technology being preceded by an information preceded period known as the awareness period. The definition of adoption considering that one is termed to be an adopter varies across studies. According to Ogunyemia and Ojo (2014), it was argued that when a farmer uses at least one of the improved technologies for at least one season then one can be termed as an adopter. According to Nkonya (2001) improved seeds are defined as any seeds bred through formal plant breeding methods that are highly resistant to environmental and biotic stresses that include drought, high rainfall, pests and diseases. FAO (2009) defines improved seeds as seeds that are produced aiming at increasing the productivity and quality of the crop.

2.1.2 Small holder farmers

According to FAO (2010), farmers who operate on small plots below 2hectares (5acres) are considered to be small holder farmers. Salami (2010) categorized small holder according to agro-ecological zones, basis of annual revenue and type of their farm portfolios, also Cousins (2014) defined small holder farmers according to small income, small capital, few laborers' and forming part of the poor rural people.

2.2 Beans Production and Improved Bean Seeds in Tanzania

According to Hillocks *et al.* (2006) and Fivawo and Msolla (2011), Tanzania is among the top producers of common beans being the second leading country in Sub-Saharan and East Africa as well. Bucheyeki *et al.* (2013) noted that common bean is an important food and cash crop to the country, though the average bean production is still low in developing countries compared to developed countries. According to Binagwa *et al.* (2016), beans production in Tanzania is still limited with different constraints like environmental stresses and continuous use of poor local seeds.

In Tanzania, the research on improving the bean sector goes way back in 1959 at Tengeru Agricultural Research Institute (TARI) since the aim of the programme was to combat the low production farmers' experienced (Letaa *et al.*, 2015). Hence from that time a lot of improved varieties have been produced and disseminated to different beans producing regions in the country whereby some of these varieties have been a major help to farmers. From these efforts, between 2001 and 2015, a total of 34 improved varieties were introduced with multiple resistances to environmental factors and high nutritional value compared to earlier released varieties (PABRA database, 2015).

The Pan Africa Bean Research Alliance (PABRA) is also among the institutions which aimed at increasing bean productivity for farmers and also opening marketing channels for them and therefore, with alliance with other private and public institutions some of them being CIAT, NARS, ARI Uyole and SUA, many varieties were developed, and by 2011, a total of 200 varieties including new and improved varieties were developed that were aimed by 2013 to reach as many households as possible (Chirwa *et al.*, 2012). Some of the few improved varieties that were introduced at ARI in 2012 season and are still disseminated to farmers in different regions of the country and used are shown in Table 1.

According to Xinhua (2016), Tanzania researchers introduced a total of 27 new varieties whereby among these nine of them were improved, resistant and highly nutritious. These varieties have been proved to have low acidic content and less sensitivity for people who avoided beans in the past, also were said to have very higher yields, which is six times higher than for local varieties.

Table 1: Breeder seeds produced at ARI Uyole in Tanzania during the 2012 season

Variety	Area planted	Seed produced (bags-100kgs)
Njano-Uyole	1.00	8.0
Uyole 96	1.00	8.0
Uyole 04	1.00	6.0
Uyole 03	0.75	5.0
Roba I	0.25	2.0
Calima-Uyole	0.25	2.5
Uyole 94	0.25	2.0
Kabanima	0.25	2.0
Urafiki	0.25	2.5
Uyole 98	0.25	2.0
Wanja	0.25	2.0
Total	5.5	44.0

Source: Chirwa *et al.* (2012)

2.3 Theoretical Framework

This study is governed by two main important adoption theories that include the theory of innovation diffusion and the theory of maximum utilization.

2.3.1 Theory of innovation diffusion

According to Roger (1995), the decision of farmers to adopt any technology occurs through five stages that include knowledge, persuasion, decision of whether to adopt or not, implementation and confirmation and this decision is affected by different factors. Yates (2001) points out that diffusion theory is a meta theory, which is not a single theory rather it is a collection of several theoretical perspectives that explain the stages of adoption that is affected by different factors. These factors include the nature the

innovation itself, communication channels, time and the characteristics of the social system as explained as follows.

- i. The innovation introduced whereby in this case the innovation happens to be the improved bean varieties.
- ii. Communication channels involved in the new technology. In order for any technology to be transferred from its source it requires a channel that in this case an extension agent that acts as a channel for diffusing the agricultural technology to farmers.
- iii. Time needed for the innovation to be adopted whereby it is considered to be a gradual process which starts with low adoption rate and in turn may increase or decrease depending on different circumstances.
- iv. The social system that includes different external and internal characteristics that affect the farmers' decision in adopting the improved technology. These factors are mainly grouped into socio-economic, institutional and technology characteristics. Some of these factors include age, gender, experience of the farmers and income level for socio-economic factors while institutional factors comprise of extension availability, credit facilities and market availability and technology characteristics that comprises of perception and attitudes from farmers whereby for farmers to adopt the improved or new technology it depends on the net benefits farmers expect to obtain or their experience in using the improved technology.

According to Isham (2002), the innovation diffusion theory by Roger (1995) have been tested empirically investigating the factors that affect adoption of improved technologies by farmers using data from developing countries and the socio-economic factors mentioned were viable in explaining the adoption of improved technologies. These

factors include age, gender, experience, income, land size, access to finance, price of the technology, labour availability, participation in off-farm activities, land tenure, market availability and extension services.

Furthermore, Rogers explains the five stages of the adoption process as follows:

- i. Knowledge stage, that is considered that at first as the individual is introduced to the new technology or innovation, he or she lacks enough information for him or her to make a decision and therefore most of these farmers will be reluctant and might not be inspired enough to adopt the new technology.
- ii. Persuasion stage, whereby by at this stage the farmer seeks to find information that will persuade him or her to use the new technology.
- iii. Decision to adopt or not whereby after obtaining the information he or she needs, a farmer then weights the details on the advantages and disadvantages of the technology according to his or her preferences and the farmer might use or not use the new innovation.
- iv. Implementation stage, whereby during this stage the farmer determines the usefulness of the innovation and may be persuaded to seek for more details on the innovation.
- v. Confirmation stage, whereby at this stage the farmer finalizes the decision to continue using the new technology according to the preferences of the farmer.

2.3.2 Theory of maximum utilization

Farmers are assumed to be risk averse and also maximize their utility, in this case their utility being maximizing profit. According to Smale *et al.* (1994) and Shampine (1998) on the economic constraint model, it assumes that the household as a unit of production and

consumption aims to maximize its utility subject to its production function, time and income constraints. This means that as accessibility to factors as income from farm and off-farm activities, farm size, credit availability, extension services and favorable prices of the technology become limited they also affect the ability of farmers' to the decision and extent of adopting new technologies. Baltz *et al.* (1999) also explains on theory of expected utility whereby it is assumed that farmers tend to choose the alternative with the highest utility since farmers are considered to maximize their perceived profits. In this case farmers usually compare traditional technology to the modern ones introduced. These farmers will adopt the improved technology only if the expected utility obtained from the modern technology exceeds the traditional one.

2.4 Empirical Evidence

2.4.1 Rate of adoption

The descriptive analysis was used to summarize the data on the rate of adoption for most of the literatures. A study done by Mustapha *et al.* (2012) in Nigeria indicated that the rate of farmers' adoption to the improved technologies was promising. From the study it was noted that the recommended technologies that were considered included improved seeds, fertilizer application, agrochemicals, planting time and harvesting time. The results summary from the descriptive analysis concluded that 52.20% of the respondents adopted improved Soya bean varieties, 47.8% adopted fertilizer application, 32.2% adopted the use of agrochemicals, 56.70% adopted planting time technique and 68.9% adopted harvested time technique. The major constraints against the adoption of these technologies was poor extension services, high costs of the inputs and lack of credit facilities to beans farmers.

Langyintuo *et al.* (2008) noted that the adoption rates of improved seeds ranged from less than 10% in Angola, 10% to 25% in Ethiopia, Malawi, Mozambique and Tanzania to >70% in Kenya and Zambia in 2007. According to Tiamiyu *et al.* (2009) in Nigeria, low levels of improved rice adoption by the rice farmers proved the dominance of local varieties in the area. The mean score was 45% for the respondents who adopted the higher technology while leaving 55% in the lower level technology. The factors that happened to be significant in explaining the adoption of improved rice variety happened to be farmers' education, extension services, experience and credit accessibility.

2.4.2 Determinants of adoption decision and intensity of adoption of improved varieties by farmers

Based on the study done by Tiwari (2010) on economic and technological constraints facing farm women in India, it was noted that major factors that affected women in accessing improved seeds and fertilizer was poor accessibility of extension services, lack of credit facilities, lack of training programmes to women to develop their agricultural and technological skills and also the Government seeds and fertilizer stores did not make these inputs available to women on time. Therefore it was recommended that in order to improve the adoption rates of women in improved agricultural practices literacy rate of women should be improved, women must be empowered, sufficient loans should be available and cost of inputs should be reasonable and affordable. According to Oladeji *et al.* (2015) on determinants of adoption of improved rice varieties in Nigeria, the Heckman model was used to analyze these determinants. The results showed that income and credit accessibility had a positive influence to the probability of a farmer in adopting improved rice varieties. For the intensity of use of improved rice varieties, gender and farm size positively affected the intensity of use of the varieties while household size negatively influenced the extent of use by adopters. A study by Awotide (2014) on the extent and

determinants of adoption of improved cassava varieties in Nigeria, argued that gender negatively influenced the adoption decision of farmers to the use of improved cassava varieties. while education, credit accessibility and farm land positively influenced the adoption probability. Labour was the only factor that influenced the extent of use of the improved cassava varieties, where by it had positive influence.

Furthermore Okorie (2012) listed factors like labour price, fertilizer price, household size, age of respondents positively affected the decision of farmers to adopt the improved seeds while farm size negatively influenced the decision of farmers in adoption. As for the intensity of using the improved cassava varieties age only happened to affect intensity positively while labour price, fertilizer price and household size negatively affected the intensity of the varieties.

2.5 Econometric Analysis

2.5.1 Econometric models for adoption

According to Feder and Zilberman (1985) in Teferi (2013), it is observed that since the decision of a farmer to adopt any technology at a specific time is derived from the expected profit or maximized utility subjected to resource constraints, then in determining what factors affect this decision or the intensity of the adopted technology static models are highly preferred than dynamic models since with static model the decision to adopt at a specific time and place is what is considered.

Some of the static models are binary in nature considering a dependent variable with a probability nature example the logit and the probit models but these models being limited to analyzing quantitative information about the adoption decision only. Some models like the Heckman model and the double hurdle model go beyond in assessing quantitatively

the intensity of the technology adopted (Heckman, 1979). According to Heckman (1976), the choice of any model is very important since it influences the empirical results obtained and if used wrongly it may affect the information reliability.

2.5.2 Heckman sample selection model

This model was developed by Heckman (1979) and has been used in some adoption studies instead of the OLS that isn't appropriate for binary or probability studies, probit and logit models that only measure the probability of adoption but not intensity of adoption and the Tobit model that assumes factors that affect adoption decision and intensity are the same. Since the Heckman model not only measures the adoption decision but also the intensity of adoption, it assumes that factors of adoption decision and intensity can be different and corrects for the selection bias problem therefore the model is considered to be fit for these adoption studies.

Different studies that analyzed both the factors affecting the adoption decision and intensity of adoption have used the Heckman two step model and some of them include a study by Oladeji *et al.* (2015), used the Heckman model in analyzing the factors that affect awareness and adoption of improved rice varieties in Nigeria. Significant factors that affected the adoption decision of the rice farmers were income and credit accessibility while gender, household size and farm size affected the intensity of use. Awotide *et al.* (2014) used the Heckman model in assessing the extent and determinants of adoption of improved cassava varieties in South-western Nigeria whereby gender, education, credit and farm size significantly affected the adoption probability while labour affected the intensity of use.

According to Ibrahim *et al.* (2012), the Heckman two step model was also used in assessing determinants of adoption of improved peanut varieties in Ghana whereby Okorie (2012) also used the Heckman model to assess the determinants of level of adoption of improved cassava varieties in Nigeria and the significant factors were labour price, fertilizer price, household size, age and farm size.

2.5.3 Gross Margin analysis

According to Tsinigo *et al.* (2016), gross margin was used as a proxy for profitability of the enterprise. In their study, gross margin was used to compare the profitability of rice production in Ghana. Sadiq *et al.* (2013) also used the gross margin analysis to analyze the profitability of maize whereby from these studies profitability was observed to be favorable to farmers compared to the low costs they used in production. In a study by Katungi *et al.* (2017) on a report on improved bean varieties in Malawi, it was noted that from the results of the gross margin analysis adopters of improved bean seeds obtained higher yields compared to non-adopters because the improved seeds were very resistant to several constraints. According to Shalma (2014), gross margin was used to estimate the profitability of soya bean in Kaduna State, Nigeria. Abdullahi (2012) compared the profitability of the improved rice varieties and the local varieties through the gross margin analysis and it was noted that the profitability of the improved varieties came along with farmers following the recommended agronomic practices.

2.6 Conceptual Framework

Adoption decision of any technology and its intensity of use is influenced by a number of socio-economic and institutional factors. According to Isham (2002), some of these factors include education level of the farmer, farmer's experience, age of the farmer, gender, farm size, off-farm activities, price of the technology adopted, credit availability

and extension services. Figure 1 shows the interlink between these socio-economic and institutional factors and the outcome of farmers in adopting new and improved bean varieties. It is assumed that these factors may affect one's ability in the adoption decision and intensity of use of the improved varieties whereas it may also affect the rate in which adoption of any technology have taken place (the number of adopters and non-adopters), which in turn affects the farmers' yields, income levels and their profit margins. It is also assumed that as farmers' adoption perception changes in turn it also affects yields, income levels and profit margins they obtain.

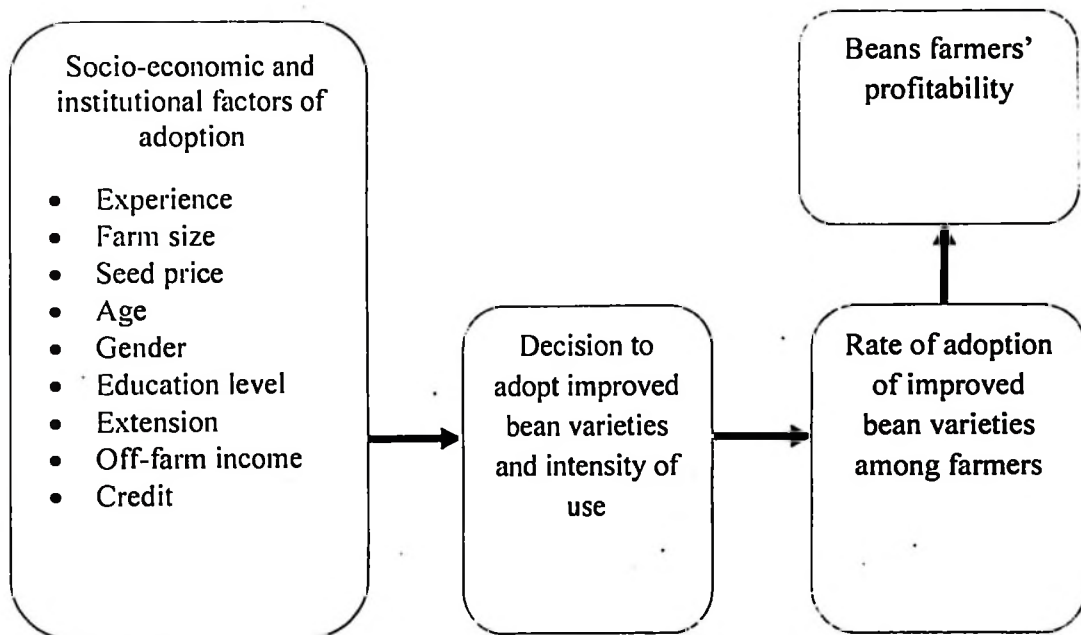


Figure 1: Conceptual framework

Source: Modified from Raphael (2014)

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Mbeya rural district located in Mbeya region. The study area was selected purposively because it was more accessible compared to other places and also due high potential for producing beans. Mbeya region is among the regions in the country that produces and supply beans that the country depends on for food security and sustainability. According to MAFC and NBS (2012), it was noted that the total production of beans is about 95.19 tons/ha per annum. Mbeya region lies between latitude 7°9' 31' South of the Equator and 32° and 35° East of Greenwich. This region is bordered to the West by Malawi and Songwe, by Singida and Tabora regions to the North and by Njombe and Iringa regions to the East. According to the National Bureau of Statistics of Tanzania (NBS, 2012), Mbeya rural district has an area of 2432 km² and a population of 433186.

3.2 Research Design

Cross sectional data was collected considering that information at the specific time was needed. The targeted population was beans farmers located at Mbeya rural district who had planted different beans varieties in the season of the year 2015/16.

3.3 Sampling Procedure and Sample Size

Multistage sampling technique was used whereby in the initial stage Mbeya region was purposively chosen for data collection in the study since it is among other regions with higher production of beans in the country. In stage two, Mbeya rural district was also purposively chosen due to its accessibility with the available provided funds, from the district then two wards were randomly selected which were Utengule Usongwe and

Mshewe wards in which Itimba, Muvwa and Mshewe villages were also randomly selected. From the three villages, a total of 210 farmers were randomly selected too whereby 59 farmers were from Itimba, 76 farmers from Muvwa, and 75 farmers from Mshewe.

Sample size determination was estimated by the Cochran's formular. According to Mugenda (2003), Cochran's formular is one of the appropriate ways on determining the sample size. The procedure through which the sample size was determined is shown below.

The Cochran's formular

$$n = \frac{z^2 pq}{e^2} \dots \dots \dots (1)$$

Whereby n is the sample size, z is the confidence level which is 1.96 and corresponds to 95%, e is allowable error which is 0.05, p is proportion of the population and is obtained by (1-q). Since we calculate a sample size of a large population whose degree of variability is not known, we assume the maximum variability which is equal to 50% (p=0.5). Hence if p is obtained by (1-q), then q will also be 0.5.

$$n = \frac{(1.96^2)(0.5)(0.5)}{0.05^2}$$

n= 384 respondents.

From the formular the sample size was determined to be 384 respondents, however a sample size of 210 respondents was taken because of financial and manpower constraints. According to Kothari (2004) it was noted that a sample size with at least 120 respondents was considered satisfactory for a good analysis.

3.4 Data Type and Methods of Data Collection

Both primary and secondary data were used for the study. Primary data was collected through structured survey questionnaires and interviewing beans farmers on their socio-economic characteristics such as age, experience, access to credit, gender, education status, access to education and farm production information such as farm size, quantity of seeds used, quantity of agrochemicals used, number of laborers and the output obtained. For secondary data, information was obtained from different journals and reports concerned with adoption of improved technologies studies.

3.5 Data Processing and Analysis

Survey data was coded and summarized in Statistical Package for Social Science software (SPSS) and STATA whereby both of them were used for analysis. Descriptive and econometric analysis were used for analyzing the collected data whereby the econometric analysis was done through the Heckman model and the gross margin analysis.

3.6 Data Analytical Framework and Model Specification

3.6.1 Determining the rate of adoption

The first specific objective on determining the rate of adoption of improved bean varieties among beans farmers' was analyzed descriptively. Descriptive statistics such as the central tendency (frequency distribution and percentages) was used in summarizing the number of farmers who adopted to the use of improved varieties and the ones who did not adopt, also the rate (number) of adopters and non-adopters was summarized by the farmers' socio-economic factors (gender, age, education, experience, household size, extension, credit, off-farm income and farm size). The descriptive analysis was done prior to the Heckman model that was used to assess the factors that influenced farmers' decision and intensity of adoption.

3.6.2 Determining factors influencing adoption decision and intensity of adoption

The second specific objective was analyzed through the Heckman two-step model. The Heckman two-step model was used because of its superiority over the linear models like the OLS regression. This is because the OLS doesn't account for probability as for the binary equations and hence being the reason of why many adoption studies use binary models.

Comparing a the Heckman model over other probability models like probit, logit and the Tobit models, Heckman model is superior over the probit and logit models. This is because it goes beyond by analyzing the intensity part which is continuous compared to these models, also Heckman is still superior over the Tobit model since with the Tobit model factors affecting the decision and intensity of adoption are assumed to be the same while it's not necessary in all cases. This was why the study employed the Heckman model since these factors do not necessarily have to be the same and hence having two stages in the model it allowed for correcting the sample selection biasness.

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The Heckman two-step model was used to analyze the factors influencing the adoption decision and the intensity of adoption of the improved bean varieties. The variables included in the model were experience, farm size, seed price, age, gender, education, extension access, off-farm income and credit accessibility. The Heckman two-stage model is divided into two parts, one being the probit model that analyses the selection criteria on the decision of decision to adopt and second being the OLS regression that analyses the outcome criteria that only involves farmers who adopted the improved seeds. After the two-stage analysis, the post estimation of the selection equation (the probit part) was done to obtain the marginal effects.

SNAL

$$\frac{\partial E(\frac{y}{x})}{\partial x} \dots\dots\dots (2)$$

According to Heckman (1979), marginal effects were used for interpreting the first stage only since the coefficients of the selection equation only maximize the likelihood function and have no direct interpretation.

For the first model that is the probit model the dependent variable is the probability that is whether one adopts=1 or whether one does not adopt=0 and this can be shown as below.

$$pr (y_i=1|w_i\alpha) = \Phi (h(w_i\alpha))+e_i\dots\dots\dots(3)$$

Whereby y_i =Indicator variable equal to the unit of farmers who adopted the improved seeds

Φ =Standard normal cumulative distribution function

w_i =Vector of factors affecting decision

α =Vector of coefficients estimated

e_i =Error term that is normal distributed

$y_i=1$ if the Marginal utility the farmer obtains from adoption is greater than 0 and otherwise

$$y_i^*=\alpha w_i+ u_i\dots\dots\dots(4)$$

Whereby; y_i^* =latent variable reflecting the utility obtained from adoption (unobservable) that is influenced by the explanatory variables in the equation

$$u_i \sim N(0,1)$$

$$y_i=1 \text{ if } y_i^*>0\dots\dots\dots(5)$$

$$y_i=0 \text{ if } y_i^*\leq 0\dots\dots\dots(6)$$

In the second step an additional regressor which is the Inverse Mills Ratio (IMR) was included in the intensity equation so as to correct for the selection bias, the IMR is computed as follows

$$\frac{\phi(h(w_i, \bar{a}))}{\Phi(w_i, \bar{a})} \dots\dots\dots (7)$$

Where by Φ is the normal probability density function

For the second stage that is the outcome equation, the OLS regression can be expressed as follows

$$y_i^* = B_1 X_i + B_2 \lambda + \mu_i \quad \text{if } y_i^* > 0 \dots\dots\dots (8)$$

Whereby; y^* =proportion of improved seeds this being limited only for the adopters

X_i =Vector of explanatory variables

B_i =Vector of estimated coefficients

B_λ =Coefficient of the mills ratio

λ =Inverse Mills Ratio (IMR)

μ_i =Error term

For the first stage (the probit model)

$$P_i(0, 1) = B_0 + B_1 X_1 + B_2 X_2 \dots\dots\dots + B_n X_n + e \dots\dots\dots (9)$$

$$P_i(0, 1) = B_0 + B_1 X_{\text{experience}} + B_2 X_{\text{farm size}} + B_3 X_{\text{seed price}} + B_4 X_{\text{age}} + B_5 X_{\text{gender}} + B_6 X_{\text{education}} + B_7 X_{\text{extension}} + B_8 X_{\text{offfarm activities}} + B_9 X_{\text{credit}} + e_i \dots\dots\dots (10)$$

For the second step (the OLS regression model)

$$y_i = B_0 + B_1 X_1 + B_2 X_2 \dots\dots\dots + B_n X_n + e \dots\dots\dots (11)$$

$$\text{Proportion of improved seeds quantity } (y_i) = B_0 + B_1 X_{\text{experience}} + B_2 X_{\text{farm size}} + B_3 X_{\text{seed price}} + B_4 X_{\text{education}} + B_5 X_{\text{extension}} + B_6 X_{\text{offfarm activities}} + B_7 X_{\text{credit}} + e_i \dots\dots\dots (12)$$

Table 2: Expected signs of the explanatory variables in the Heckman selection model

Variables	Measurement	Expected signs	Description
Experience	Years (continuous)	+	The more experienced a farmer is, he or she has a high likelihood to adopt improved varieties.
Age	Years (continuous)	+/-	Older farmers are more conservative to improved technologies compared to younger farmers. On the other hand due to lack of experience, young farmers may deny the use of new technologies.
Gender	Dummy(1=male,0=female)	+	Male farmers are expected to adopt the use of improved seeds compared to females.
Education	Dummy(1=Above secondary,0=primary and uneducated)	+	Educated farmers are predicted to adopt to new and improved technologies compared to uneducated farmers.
Extension	Dummy(1=yes, 0=no)	+	Farmers who have access to extension services have high likelihood to adopt to improved seeds.
Off-farm activities	Dummy(1=yes,0=no)	+	Farmers who depend on off-farm activities have high likelihood in adopting improved seeds since they obtain added income compared to others.
Credit	Dummy(1=yes,0=no)	+	Credit facilitates farmers in adopting to new technologies.
Farm size	Acres(continuous)	+/-	Large farm size owners are more likely to adopt to improved seeds. On the other hand farmers with small farm sizes may adopt to improved seeds since they may want to intensify their production.
Seed price	Shillings(continuous)	-	As seed price increases, it lowers the adoption of farmers to improved seeds.

3.6.3 Comparing the profit margins of common beans production between adopters and non-adopters

The third objective was analyzed through the gross margin analysis (GM) that was employed to determine the costs and returns associated with production of the improved and local varieties. The variable costs accrued and the revenue obtained by beans farmers

was used. Fixed costs were ignored since the gross margin analysis assumes that fixed costs hardly affects the sustainability of enterprises.

The gross margin analysis can be specified as shown below.

$$GM = \sum TR - \sum TVC \dots \dots \dots (13)$$

Where by GM stands for gross margin, TR for total revenue (obtained by price of selling beans times quantity output), TVC for the total variable costs incurred (obtained by price of buying seeds times quantity bought). For this case the revenue each farmer obtains per acre was multiplied by the average price of the beans sold that was obtained. Variable costs per acre associated with production were also included (costs of seeds used, labour, fertilizer, herbicides, hired land and transportation). Then an independent t-test was performed to establish a significant difference in farmers' profit margins between adopters and non-adopters in terms of variable costs, gross revenue and gross margin values. The test was carried out basing on the mean differences of the two groups.

3.7 Multicollinearity Test

Multicollinearity test was performed in SPSS before running the Heckman model and the Variance Inflation Factor (VIF) and the tolerance values were considered. The VIF formular was obtained through the reciprocal of the tolerance values of the independent variables. According to Daoud (2017), tolerance value is the amount of variability in one independent variable that is not explained by other independent variable whereby the value is obtained by $1 - R^2$. He also noted that when the VIF happens to be between 5 and 10 then there is serious problem of high multicollinearity.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of the Respondents

4.1.1 Gender of the respondents

The results from the study as indicated in Table 3 show that most of the farmers in the study area were male respondents. The male respondents accounted for 60.95% of the farmers while female respondents present were 39.05%. According to Duze and Mohammed (2006) patriarchy and male dominance in decision making in most of the African societies is due to most of these households being led by men. This indicates that most of the men are involved in most of the economic activities so as to provide for their families and improve their economic conditions. There is also a tendency of men to engage themselves in agriculture for cash crop purposes and females for food crops purposes unless when excess outputs are realized and can be sold (Mdoe and Macha, 2002).

4.1.2 Age of the respondents

The results in Table 3 indicate that most of the household heads had ages ranging between 25 and 44 years that is 49.52%. followed by 36.05% between 45 and 64 years, followed by 8.10% who were above 65 years and then followed by 3.33% with less than 25 years. This implies that most of the farmers were mid aged farmers who were capable of engaging themselves in productive agricultural activities. This can supported by a study by Oyewole and Ojeleye (2014) who reported that mid aged farmers seem to be energetic than older farmers and can do a lot of farm activities if given proper incentives.

4.1.3 Education level of the respondents

The results in Table 3 show that 9.53% of the respondents were uneducated, 80.5% had primary education, 7.62% had secondary education and 2.38% had above secondary education. This implies that farmers who were uneducated were very few in number and hence most of the farmers were at least educated. Education level enhances farmers in decision making capabilities when it comes to agricultural production example adopting new improved agricultural technologies (Mustapha *et al.*, 2012). According to Das and Sahoo (2012) education was noted to be important in rural development as it is reflected through agricultural development whereby most of the farmers are located in rural areas.

4.1.4 Household size of the respondents

From the results of the study as seen in Table 3, it is shown that 69.04% of the farmers had between 1 and 5 family members, 30.00% of them had family members between 6 and 10 and only 0.96% had a total of above 10 members. Family labour is an important aspect in agricultural production since with labour availability it becomes easier in production especially when it is not hired labour that is usually somehow expensive to farmers. The results are also supported by Namwata *et al.* (2010) who noted that family size corresponds to family labour since it provides costless labour for farm activities. According to Raphael (2014), family size plays a great role in family labour provision in agricultural production, however it can't be used to justify productivity because it can be affected by other factors like gender, age and health status.

4.1.5 Off-farm activities

From Table 3, the results indicate that 71.90% of the farmers were engaged only in agriculture while 28.10% engaged in both agricultural and non-agricultural activities. This implies that agriculture is the backbone of the economy of most of developing

countries and it is the main activity of most of the rural people. This is also evidenced by World Bank (2017), which showed that the agricultural sector is the main sector and the keydriver of the Tanzania economy having about 70% of the people engaged and generates about 29.1% of the national GDP.

4.1.6 Farm size

The results from the study as presented in Table 3, indicated that 68.09% of the farmers cultivated less than 1 hectare of farmland, while 28.09% cultivated between 1 and 2 ha and only 3.82% cultivated above 2 ha of farmland. This implies that land being also one of the necessary assets in production this implies that most of these farmers were small holder farmers and most of them produced beans for both consumption and commercial purposes instead of commercial purpose only. According to FAO (2010) it was noted that farmers who operated below 2 ha were considered to be small scale farmers with small sized farms. The results were also in agreement with the study by Mustapha *et al.* (2012) who indicated that most of the beans farmers were small scale farmers.

Table 3: Socio-economic characteristics of respondents in Mbeya rural district

Characteristics		Frequency	Percentage
Gender	Male	128	60.95
	Female	82	39.05
	Total	210	100.00
Age	<25	7	3.33
	25-44	104	49.52
	45-65	82	39.05
	>65	17	8.10
	Total	210	100.00
Education	Not educated	20	9.53
	Primary	169	80.48
	Secondary	16	7.62
	Above secondary	5	2.38
	Total	210	100.00
Household size	1-5	145	69.04
	6-10	63	30.00
	>10	2	0.96
	Total	210	100.00
Off-farm income	Yes	59	28.10
	No	151	71.90
	Total	210	100.00
Farm size	<1ha	143	68.09
	1ha-2ha	59	28.09
	>2ha	8	3.82
	Total	210	100.00

4.2 Common Bean Varieties Grown in the Study Area

4.2.1 Improved bean varieties grown

A total of six common bean varieties were used by farmers in the study area. Three of these varieties used by farmers were improved varieties. These varieties were Uyole 03, Uyole 96 and Kipapi variety. Uyole 03 was grown by 68% of the farmers while Uyole 96 variety was grown by 22% of the farmers and Kipapi variety being used by 10% of the farmers. These varieties were mostly grown by farmers due to their favorable characteristics such as early maturity, high yielding, nutritional value and being marketable. Figure 2 illustrates improved bean varieties grown in the study area in the order of their importance.

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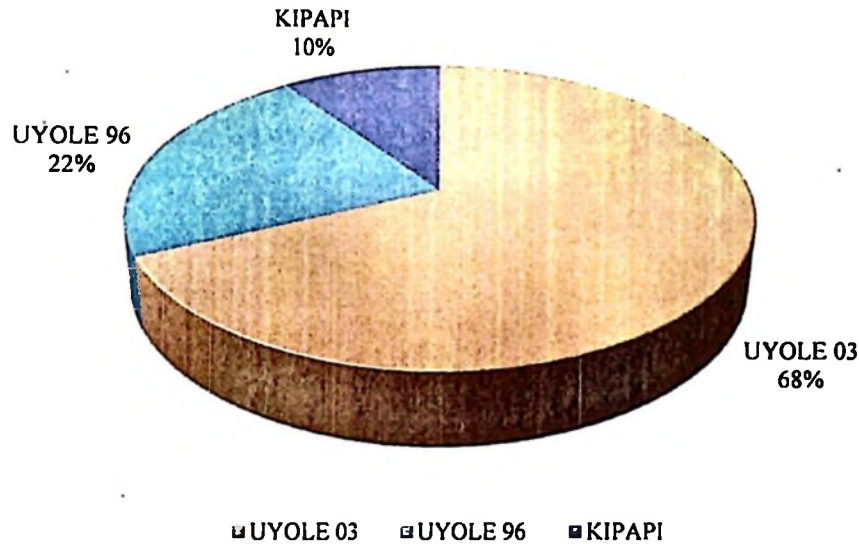


Figure 2: Some of the improved bean varieties grown in Mbeya rural district for the year 2015/16

4.2.2 Local bean varieties grown

For the local varieties, three varieties were grown by farmers. These varieties were Masusu, Kablanketi and Soya Njano varieties. The Njano variety was highly grown by farmers that constitutes of 60% of the farmers, followed by Kablanketi variety that was grown by 27% of the farmers and Masusu variety being grown by 13% of them. Soya Njano variety was highly used by farmers because it is highly marketable as well as good taste. According to SAT (2014), Soya Njano variety is a local variety that is used by many small holder farmers in Tanzania because of its good taste that makes the variety highly marketable. The Masusu variety was used by some of them due to its disease resistance characteristics, whereby this can be supported by Gebeyehu *et al.* (2006) whereby he noted that Masusu variety still being a local variety but was also resistant to some diseases. The challenges that farmers faced with the local varieties was poor yields since most of these varieties were not resistant to high rainfall, diseases and drought

leading to losses to some farmers. Figure 3 below illustrates the local varieties that were grown in the study area.

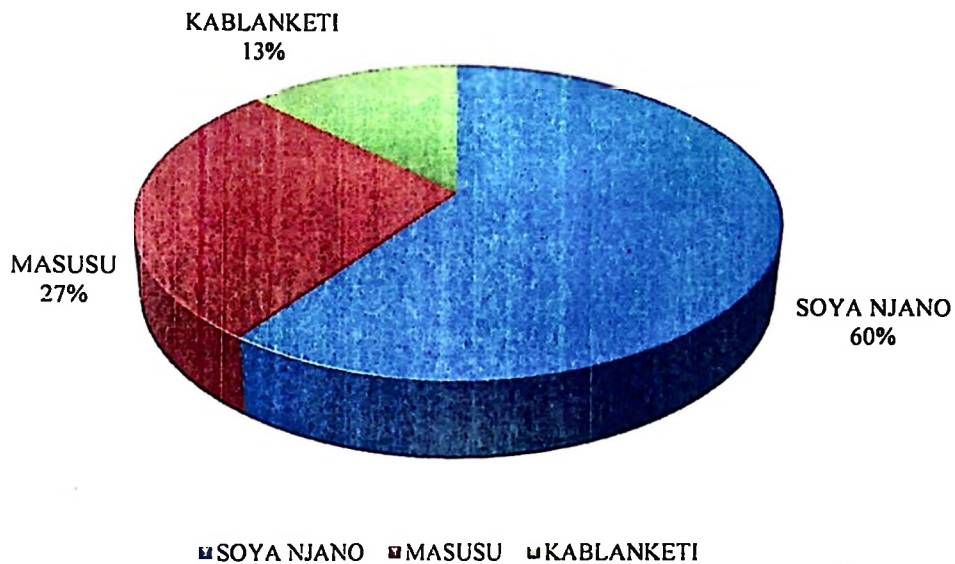


Figure 3: Some of the local bean varieties grown in Mbeya rural district for the year 2015/16

4.3 Empirical Results

4.3.1 Rate of adoption of the improved bean varieties

The descriptive analysis was employed for the first objective to analyze the rate of adoption of improved bean varieties among farmers in the study area through frequencies and percentages that show the number of adopters and non-adopters. The socio-economic factors that explained the difference between the two groups of farmers were gender, age, education, experience, family labour, extension, credit availability, off farm activities and farm size. The descriptive statistics results in Table 4 show that 31.4% of the farmers among the respondents were adopters of improved bean varieties while 68.6% of them used local varieties. In the study, for one to be considered to be an adopter of the

improved bean seeds, only farmers who had at least used one of the improved seeds for two and above years including the year 2015/16 were considered.

Table 4: Descriptive analysis on the rate of adoption of farmers in the study area

Variety	Frequency	Percent (%)
Local	144	68.6
Improved	66	31.4
Total	210	100.0

4.3.2 Influence of socio-economic factors on adoption: a descriptive analysis

From the results shown in Table 5 the distribution of adopters based on gender indicated that 21.45% of the male group were adopters while for female only of 9.99% of them had adopted the improved varieties. This indicates that men were likely to adopt the improved varieties than men though both of these groups had low adoption rates. This can be due to the fact that the male headed household had more control to most productive resources such as capital and land. This can be supported by the study done by Oladeji *et al.* (2015) whereby it was reported that more of the men adopted the improved rice varieties compared to women due to the fact that men have more open access to economic resources than women.

Most of the farmers from the two groups belonged to the mid age group. From the results presented in Table 5 it is shown that most of the adopters were the mid-aged group that comprised of 23.82% who belonged to a group of 25-44years. The results also show that 1.42% of the adopters belonged to farmers who were above 65 years. This indicated that mid aged farmers adopted more the improved varieties compared to elder farmers. This could be due to the fact that older farmers seem to be risk averse and conservative compared to younger farmers. The study done by Kinuthia and Mabaya (2017) noted that

in Tanzania and Uganda, adopters of new technologies are relatively younger than the non-adopters, implying that as farmers age they become less open to adopting new technologies. The results were also consistent with that of He *et al.* (2007) that noted that the adoption of the irrigation technology in China was higher in young farmers compared to older farmers, this was because the older farmers happened to be conservative.

From the presented results in Table 5 it is shown that among the adopters, educated farmers had high adoption rates compared to the uneducated ones. The results showed that among the adopters 28.57% of the farmers were educated, thus implying that education provides easy understanding and creates openness to new technology. The results are consistent with the study done by Mustapha *et al.* (2012), most of the farmers (41.10%) had formal education as it implied that with the knowledge they have they could apprehend the improved bean seeds and other technologies being disseminated to them.

From the results presented in Table 5 it is shown that for adopters who were highly experienced farmers of 10-30 years and above 30 years, 30.95% of them used the improved seeds. Most of the farmers that used the improved seeds were experienced in agriculture production especially in beans production, thus this implies that as farmers become more experienced in farming also they become less conservative in using new technologies. A study done by Oyewole and Ojeleye (2014), noted that the increase in experience to farmers was influential to the use of improved varieties enhancing productivity.

Most of the household adopters of improved seeds had between 1-5 people for agricultural activities that accounted for 19.52 % of the adopters from the group as shown in Table 5. It is expected that with a higher number of people to assist in agricultural

practices, most farmers will be able to adopt improved seeds, but in this case with the higher number of members in the family, most of the households didn't use improved seeds and this may be due to the increase of the dependency factor and hence lacking enough amount of money to purchase for the improved technologies. The results are not consistent with a study done by Ayalew (2011) that reported that as the family size increases it also increase the use of new technologies as it is likely to influence the profitability of the innovation.

The results from the study in Table 5 show that 26.19% of the farmers who had access to extension services had adopted improved seeds compared to 5.24% of the adopters who didn't have access to extension services. Therefore, it seems that extension services had an influence in increasing a chance of one in adopting new technology. A study done by Letaa *et al.* (2015) noted that farmers who had access to extension services had open chances to resources and skills and hence had high chances to adoption.

Credit availability can be seen to have a positive influence in the use of improved varieties as presented in Table 5 whereby 18.10% of the adopters obtained credit from different institutions compared to 13.33% of the adopters who didn't have any source of credit. Thus implying that credit availability is important in attaining new technologies. The results are consistent with a study done by Siri *et al.* (2016), whereby it was noted that access to credit can increase a chance of one adopting to new technologies since farmers who had access to credit obtained high quantities produced for improved common beans varieties.

The results presented in Table 5 show that 22.86% of the adopters had income from non-agricultural activities compared to the adopters (8.57%) that depended upon agriculture

itself. These adopters were able to use some amount of the money from off-farm activities to obtain the improved seeds. This implies that as the farmers' income increases it would probably increase the ability of a farmer to acquire improved technology. A study done by Mbugua (2009) also noted that adoption of maize technology package in Kenya increased with the levels of off-farm income.

Among adopters, more of the small scaled farmers (28.11%) adopted to the use of the improved bean seeds compared to farmers who operated above 2 ha as presented in Table 5. This can be because these farmers wanted to increase their production levels. The results are consistent with the study done by Nyariki (2011) noted that farmers who had small farms were the ones who adopted to the improved technology, whereby this could be because they wanted to intensify their production levels. A study conducted by Lowder *et al.* (2016) on the distribution of small holder farms also categorized farmers who operated below 2 ha as small scaled farmers.

Table 5: Descriptive analysis on rate of adoption regarding socio-economic factors

Variable		Adopters (Frequency)	Non- adopters (Frequency)	Adopters (Percentage)	Non- adopters (Percentage)
Gender	Male	45	83	21.44	39.52
	Female	21	61	9.99	29.05
	Total	66	144	31.43	68.57
Age	<25	1	6	0.48	2.86
	25-44	50	45	23.82	21.43
	45-65	12	79	5.72	37.62
	>65	3	14	1.42	6.65
	Total	66	144	31.44	68.56
Education	Uneducated	6	14	2.86	6.67
	Primary	47	122	22.38	58.10
	Secondary	10	6	4.76	2.86
	Postsecondary	3	2	1.43	0.95
	Total	66	144	31.44	68.56
Experience	<10	1	13	0.48	6.19
	10-30	62	127	29.52	60.47
	>30	3	4	1.43	1.91
	Total	66	144	31.44	68.56
Family labour	1-5	41	104	19.52	49.52
	6-10	24	39	11.43	18.57
	>10	1	1	0.48	0.48
	Total	66	144	31.44	68.56
Extension	Yes	55	75	26.19	35.71
	No	11	69	5.24	32.86
	Total	66	144	31.44	68.56
Credit	Yes	38	22	18.10	10.48
	No	28	122	13.33	58.10
	Total	66	144	31.44	68.56
Off-farm income	Yes	48	11	22.86	5.24
	No	18	133	8.57	63.33
	Total	66	144	31.44	68.56
Farm size	<1 ha	6	137	2.86	66.22
	1 ha-2ha	53	6	25.25	2.86
	>2ha	7	1	3.33	0.48
	Total	66	144	31.44	68.56

4.3.3 Influence of socio-economic factors on adoption and intensity of adoption of improved bean varieties

After the descriptive analysis on the first objective that summarizes the rate of adoption of respondents through the influence of socio-economic factors in terms of frequencies and percentages, the Heckman model was employed to identify the socio-economic factors that influence farmers' adoption decision and intensity of use of improved bean seeds.

Multicollinearity test was performed in SPSS before running the Heckman model and the tolerance values of the independent variables were greater than 0.2 while the Variance Inflation Factor (VIF) of these variables also happened to be less than 5 showing very minimum collinearity between independent variables indicating no problem of multicollinearity from the data collected. The VIF formula was obtained through the reciprocal of the tolerance values of the independent variables. Daoud (2017), stated that when the VIF happens to be between 5 and 10 then there is a serious problem of high multicollinearity.

Results from the Heckman model that is shown in Table 6 indicated that the model was appropriately specified with an overall chi-square of 49.95 that was significant at 1% ($p > \chi^2 = 0.0000$). The inverse mills ratio (λ) was significant at 1% (0.005) and being significant it implies that the covariates of the proportion of improved seeds used is conditional on the probability of adoption showing that the selection biasness problem is solved. According to Oladeji *et al.* (2015), the inverse mills ratio from the Heckman model was significant. This implies that the covariates of the proportion grown to improved rice variety being conditional on the probability of adoption showing that there is no sample selection bias problem. The positive sign of ρ shows that the unobservable factors that increase the probability of adoption increases the intensity of adoption and vice versa.

To determine the factors influencing the adoption decision of farmers in Mbeya rural district, a probit model was estimated at the first stage of the Heckman selection equation as presented in Table 6. Four variables were significant in influencing adoption choice of farmers. These variables included farm size, improved seeds price, education, and extension services accessibility. Post estimation of the selection equation results was done

so as to obtain the marginal effects, whereby the marginal effects were used for interpretation. The marginal effects were used for interpretation since the coefficients of the selection equation have no direct interpretation (Sigei *et al.*, 2014; Heckman, 1979).

Table 6: Heckman sample selection model showing determinants of adoption choice

Variables	Coefficient	Std.error	P z	Marginal effect
Experience	-0.0023	0.0287	0.937	
Farm size	0.7136	0.3574	0.046	0.04361**
Seed price	-0.0004	0.0002	0.028	0.00003**
Age	0.0105	0.0198	0.596	
Gender(1=male,0=female)	0.5650	0.5312	0.288	
Education(1=above secondary and secondary, 0=primary and uneducated)	8.0142	4.6764	0.087	0.49014*
extension(1=yes,0=no)	1.6330	0.8070	0.043	0.09987**
Off-farm income(1=yes,0=no)	0.4172	0.6400	0.515	
Credit(1=yes,0=no)	0.4496	0.5083	0.376	
Constant	-11.9255	5.0110	0.017	
Lambda (λ)	0.5103	0.1831	0.005	
*** significant at 1% level; ** significant at 5% level; * significant at 10% level				
Wald chi ² (9)	49.95			
Prob>chi ²	0.0000			
rho (ρ)	0.7109			

Farm size was positively significant in influencing the decision of farmers in using improved bean seeds. This may be due to the fact that farmers with larger farms are believed to be a bit wealthier than farmers with small plots of land and hence being capable of buying improved seeds and use them compared to other farmers, also farmers with larger plot sizes are good risk takers than other farmers since they are able to try out a new technology while knowing that they have enough land for the traditional technologies they are used to. The marginal effect results show that the probability of adoption of the improved bean seeds is 4.36 % for farmers with larger farm sizes holding other factors constant. The results were pertinent to the study by Oladeji *et al.* (2015) that

suggested that farmers with larger farm sizes were more experimental compared to farmers with small farm sizes.

Seed price significantly and negatively affected the adoption decision whereby from the marginal effect results it is shown that increase in seed price decreases the probability of farmers in adopting improved bean seeds by 0.003% holding other factors constant. This inverse relationship between seed price and adoption decision is due to the fact that if more price is subjected for any technology the more it will drive away farmers and they will hesitate in acquiring that technology.

Education significantly and positively affected the adoption decision of farmers whereby an increase in level of education was observed to increase the adoption decision of the farmer holding other factors constant. This implies that for farmers with a secondary and above secondary level had a positive chance of using the improved seeds compared to farmers with the primary education and no education. The results were consistent to a study done by Kafle (2010) whereby it was noted that education positively affected the ability of a farmer to adopt to the use of improved seeds. This implies that education was one of the requirements of a farmer in adopting improved technologies.

Accessibility to extension services significantly and positively affected the adoption choice of farmers whereby contact between a farmer and an extension agent increases the chances of a farmer in using improved seeds other factors being held constant. This implies that for farmers who did not contact extension agents had a very lower chance of using the improved varieties. The results are consistent with a study by Akpan *et al.* (2012) whereby it was assumed that an extension agent plays an important role in diffusing knowledge of improved technologies.

The Heckman outcome equation was estimated by the OLS regression for the second step to determine the intensity of use of improved seeds as shown in Table 7, whereby farm size, improved seeds price and off-farm income were the significant variables.

Table 7: Heckman outcome model showing determinants of intensity of adoption

Variables	Coefficient	Std.error	P z
Experience	0.0028	0.0112	0.803
Farm size	0.3283	0.1348	0.015**
Seed price	0.00001	0.0004	0.000***
Education (1= above secondary and secondary, 0=primary and uneducated)	0.2578	0.2743	0.347
Extension (1=yes,0=no)	0.2551	0.2780	0.359
Off-farm income (1=yes,0=no)	0.7358	0.2110	0.000***
Credit (1=yes,0=no)	-0.0914	0.1830	0.617
Constant	-0.3409	0.4606	0.459

*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Farm size was significant and positive in influencing the intensity of using the improved seeds whereby the unit increase in farm size increased the proportion of quantity of the improved seeds holding other factors constant. Again farm size is seen to affect both the adoption decision and intensity and for farmers with larger farms was believed to be wealthier than other farmers and hence being able to adopt improved seeds and also able to buy and use larger quantities of improved seeds. According to Oladeji *et al.* (2015), farm size also had a positive relationship to the intensity of the use of the improved rice varieties and it implied that as the farm size increased the proportion of rice land cultivated increased too.

Seed price was significant and positive in influencing the intensity of using the improved seeds. It was expected to have a negative relationship with the intensity of adoption as the higher the price of these seeds was expected to influence farmers to buy these seeds in

less quantities but from the results of the study it was found to have a positive relationship. From the results, it shows that as the price of improved seeds increases by one unit it increases the intensity of use of improved seeds assuming other factors being constant. The results were not consistent with that of Abate *et al.* (2015) who noted that seed price had a negative relationship on adoption and the intensity of adoption. There might be a lurking variable that led to the results observed, for instance this can be caused by the increase in price for common beans that in turn increased the price for the bean seeds, but increase in the beans seeds motivated farmers to produce more of these improved varieties whereby they will need these improved seeds given the price incentive, therefore making these farmers prepared to buy these seeds regardless of the price.

Income from off-farm activities had a positive and significant relationship with the intensity of using the improved seeds. This implies that for farmers with income from other non-agricultural activities had a chance of using improved seeds in higher intensity than farmers who depend on income from agriculture only. The results are consistent to a study done by Akinola *et al.* (2010) whereby it was noted that farmers who had off-farm activities were able to intensify the use of the balance nutrient management technology in Nigeria since these farmers were able to buy more improved soya bean varieties to use compared to farmer who only depended on agricultural activities.

4.3.4 Gross margin analysis for improved bean seeds adopters and non-adopters

From the results in Table 8, it is observed that there are two groups of farmers (adopters and non-adopters of improved varieties) and from each group the gross margin values were calculated considering their Total Revenue (TR) and Total Variable Costs (TVC). Revenue was obtained from the total income obtained from sales of both improved and

local varieties and the variable costs were accumulated from seeds costs, fertilizer, herbicide, transportation costs, both hired and family labor and hired land.

Table 8: Costs and returns results of adopters and non-adopters of improved bean varieties

Item (per acre)	Adopters	%	Non-adopters	%
Variable costs (in tshs)				
Seeds	36 168.8	14.74	34 300.6	18.84
Fertilizer	45 911.8	18.71	32 071.4	17.62
Herbicide	10 028.8	4.09	9149.39	5.03
Transportation	15 747.3	6.42	9895.24	5.44
Labour	66 537.3	27.11	451 33.5	24.78
Hired land	71 000	28.93	51 494.3	28.29
Total Variable Cost	245 394		182 044	
Average yield (in kgs)	293.802		212.446	
Average price (in tshs/kg)	1815.54		1246.76	
Gross Revenue	533 410		264 864	
Gross Margin	288 016		82 820	

Table 9: An independent t-test between the mean differences in gross margins of the adopters and non- adopters

Categories	Mean	n	t-value	sig.
Adopters	1.3277E5	66	2.189	0.031
Non-adopters	4.9184E4	144		

From Table 8 it can be seen that the difference between the two groups is not only in the values of the gross margins of these farmers but also in the costs of the inputs they used. For instance for fertilizer and herbicides, it can be said that it was probably because many of the adopters were the ones following different agronomic practices compared to non-adopters. Most of the adopters were buying agrochemicals and fertilizers at larger quantities compared to non-adopters and probably this was why the costs used for fertilizer and herbicides adopters obtained were higher compared to non-adopters. For

seeds, it was considered that improved seeds were more expensive and were used in larger quantities than local seeds and hence for adopters who bought these improved seeds incurred a higher cost than non-adopters.

For land, labour and transportation costs, adopters experienced higher costs than non-adopters. This could be because most of the adopters had larger farm sizes compared to non-adopters that acquires higher costs for land rented, hired labourers or needing many labourers due to large farm size and efficiency. In this case, hired land and cost of labour was incurred more than other variable costs since hired land accounted for 28.93% followed by cost of labour that accounted for 27.11%. According to Abdullahi (2012), it was also noted that cost of labour incurred by the adopters of the improved rice variety was higher than other variable costs as it accounted for more than 50% of the total variable costs. For transportation, adopters incurred a higher cost than non-adopters and this could be because of higher amount of yield of these varieties that adopters could be obtaining that incurred high transportation cost compared to yields obtained by non-adopters.

The average variable cost incurred by adopters was 245 394 Tshs per acre with gross margin of 288 016 Tshs per acre while for non-adopters the average variable cost incurred was 182 044 Tshs per acre with gross margin of 82 820 Tshs per acre. This could probably be due to the reason that many adopters followed other agronomic practices (the use of herbicides and fertilizer in high amounts) along with the use of the improved seeds that made the adopters to incur higher input costs compared to non-adopters. This could imply that most of the non-adopters didn't follow the recommended agronomic practices.

After obtaining the gross margins for each group of these farmers, the independent t-test was done to test the hypothesis that improved seeds contributes in higher profit margin to farmers and if there was any significant difference in profitability between the adopters and the non-adopters group. From the t-test results in Table 9, the test statistics under the assumption of equal variances not assumed was 2.189 having a significance level of 0.031 being significant ($p < 0.05$), thus being a suitable criterion following the assumption. Therefore, the probability that there is a significant difference in profit margins between these two groups of farmers per acre is considered reflecting that the profitability difference between these two groups is influenced by not only the use of different varieties but also could be also on how these farmers employed different agronomic practices. This implies that for higher profitability levels improved seeds happened to be one of the necessary criteria but packaged with other agronomic practices too, for this case being the use of agrochemicals and fertilizer application.

Similar studies on profitability differences among adopters and non-adopters of improved varieties had also different results, some being consistent with the results obtained in this study. Abdullahi (2012) concluded that the production of improved rice variety was profitable not only due to the use of the improved seeds but also due to the fact that these farmers had used different practices like fertilizer application and use of agrochemicals compared to the local variety users. He further concludes that adopters faced a problem of high input costs and these costs should be addressed so as to encourage non-adopters to use improved seeds. According to Abiola *et al.* (2015) it was noted that the average gross margin obtained by adopters was higher compared to non-adopters of the taungya farming system. Katungi *et al.* (2017), reported that adopters of improved bean seeds obtained higher yields compared to non-adopters in Malawi because the improved seeds were very resistant to several constraints, hence there was lesser seed loss among adopters compared to non-adopters.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study examined the rate of adoption as in the number of farmers who used improved seeds and local seeds, factors that influenced the adoption decision and intensity and the profitability differences among adopters and non-adopters of the improved bean varieties. The results were obtained from the sampled bean farmers in Mbeya rural district and the following was concluded from the results.

The study has shown that about 31.4 % of the respondents adopted to the use of improved bean seeds thus implying that the adoption rate in the study area was still low. Household socio-economic characteristics considered in discussing the rate of adoption were gender, age, education level, experience, family labour, extension services, credit availability, off-farm income and farm size whereby men were observed to have higher adoption rate than women though both had lower adoption rates, educated farmers were seen to have higher adoption rate compared to uneducated farmers, farmers who had access to extension services were able to adopt to the use of improved seeds compared to adopters who had no access to extension services, whereas for farmers with between 1 and 2 hectares farm plots, adopters with credit facilities and off-farm income had a higher rate of adoption.

Factors affecting the adoption decision and intensity among these farmers were analyzed by the Heckman model and factors like farm size, seed price, education, extension services availability and off-farm income were observed to have a significant effect on decision and intensity of adoption. Farm size and seed price affected both decision and intensity of adoption while education and extension services availability were observed to

influence adoption decision alone and off-farm income was observed to influence intensity.

Furthermore, from the study it was concluded that farmers who used improved bean seeds obtained higher gross margin although they were the ones who incurred higher input costs than farmers who used the local bean seeds. This should encourage the non-adopters in adopting the improved varieties since the adopters generated higher yields that covered the costs they incurred but this will motivate the non-adopters if the costs of these inputs will be affordable especially the prices of the improved seeds.

5.2 Recommendations

From the results, still there is a need that farmers should be encouraged to the use of improved technologies. The Government should still make strong and reliable policies in subsidizing farm inputs and reducing tax on these inputs, so as to lower the cost of production that would encourage farmers in using these inputs that include improved seeds, fertilizer, herbicides and pesticides.

The Government and different private research organizations should also invest in rural education that includes formal education, workshops and trainings so as to improve the understanding of these farmers especially when it comes to new and improved innovations. This is because education has shown a positive relationship to adoption thus implying that it is important in influencing farmers decision to adoption, also extension agents should be encouraged to disseminate adequate information about different improved technologies that includes improved seeds and other agronomic practices so as to help these farmers achieve higher yields and profitability.

REFERENCES

- Abate, T., Bekele, S. and Menkir, A. (2015). Factors that Transformed Maize Productivity in Ethiopia. A Working Paper on Food Security. 17pp.
- Abdullahi, A. (2012). Comparative economic analysis of rice production by adopters and non- adopters of improved varieties among farmers in Paikoro local government area of Niger State. *Journal of Basic and Applied Science*. Department of Agricultural Economics and Extension Technology. Federal University of Technology. pp146-151.
- Abiola, M. O., Omidiji, D. A. and Umeh, D. N. (2015). Comparative analysis of the poverty and profitability status of adopters and non-adopters of sustainable Taungya farming in Ogun State. Federal University of agriculture, Abeokuta, Nigeria 3(39).
- Acheampong, P. P. (2015). Economic analysis of farmers' preferences for cassava variety traits: implications for breeding and technology adoption in Ghana. Faculty of Agriculture College of Agriculture and Natural Resources. Kwame Nkrumah University of Science and Technology. 230pp.
- African farming. (2017). [news.africanfarming.com.] site visited on 15 June 2018.
- Akinola, A., Alene, A. and Adeyemo. R. (2010). Determinants of Adoption and Intensity of use of Balance Nutrient Management Systems Technologies in the Northern Guinea Savanna of Nigeria. *Journal of International Agriculture* 49(1): 25-45.

- Akpan, S. B., Veronica, S. and Essien, U. A. (2012). A double hurdle model of fertilizer adoption and optimum use among farmers. Southern Nigeria. *Journal of Tropicultura* 30(4): 249 – 253.
- Antolini, L. S., Scare, R. F. and Dias, A. (2015). Adoption of Precision Agriculture Technologies by Farmers: a Systematic Literature Review and Proposition of an Integrated Conceptual Framework. pp. 1-17.
- Arulbalachandran, D. and Mullainathan, L. (2009). Changes on protein and methionine content of black gram (*Vignamungo* (L.) Hepper) induced by gamma rays and EMS. *American-Eurasian Journal of Scientific Research* 4: 68-72.
- Asfaw, A. and Blair, M. (2014). Quantification of drought tolerance in Ethiopia common bean varieties. *Journal of Agricultural Sciences*. Hawassa Agricultural Research Centre. South Agricultural Research Institute. Ethiopia 5(2): 16.
- Awotide, B. A., Abdoulaye, T. and Alene, A. (2014). Assessing the extent and determinants of adoption of improved cassava varieties in South-western Nigeria. Department of Agricultural Economics. University of Ibadan, Nigeria. 6(9).
- Ayalew, A. (2011). *Factors Affecting Adoption of Improved Haricot Bean Varieties and Associated Agronomic Practices in Dale Woreda, Snnprs*. Department of Plant and Horticultural Sciences. University of Hawassa, Ethiopia. 121pp.
- Babu, S. and Sanyal, P. (2010). Capacity Strengthening for Agricultural Policy Analysis and Research in Nigeria-A Roadmap towards a Strategy Report No. NSSP006. Nigeria, February 2010.4pp.

- Batz, F. J., Peters, K. and Janssen, W. (1999). The influence of technology characteristics on the rate and speed of adoption. *Agricultural Economics* 21: 121-130.
- Binagwa, P. H. (2016). State of the Art National Report: Phaleolus Bean Research Program. Selian Agricultural Research Institute Arusha-Tanzania.
- Bucheyeki, T. L. (2012). Characterization and genetic analysis of maize germ plasm for resistance to Northern Corn Leaf Blight Disease in Tanzania. Thesis for Award of PhD Degree at University of KwaZulu-Natal, Pietermaritzburg, South Africa. 183pp.
- Climate Change Agriculture and Food Security (CCAFS), (2015). A report from CGIAR research program on climate change, Agriculture and Food security.
- Chirwa, R., Rubyogo, J. C. and Mazuma, E. (2012). Getting Back to basics: Creating Impact Oriented Bean Seed Delivery System for the Poor (and others) in Malawi, Mozambique and Tanzania Annual Report 2012 for the Mc Knight Foundation's Collaborative Crop Research Program.
- Cousins, B. (2014). Working paper 16. Land and Agrarian Studies at PLAAS.
- Daoud, J. (2017). Multicollinearity and Regression Analysis. *Journal of Physics. Department of Science in Engineering*. DarulEhsan, Malaysia. 7pp.
- Das, A. and Sahoo, D. (2012). Farmers' educational level and agriculture productivity: a study of tribals of KBK districts of Odisha. *International Journal of Education Economics and Development* 3(4): 363-374.
- Deloitte (2017). Tanzania Economic Outlook. Joining the dots. A working review paper. 17pp.

- Dimara, E. and Skuras, D. (2003). Adoption of agricultural innovations as a two-stage partial observability process. *Journal of Agricultural Economics*. Department of Economics. Greece. pp.187-196.
- Duze, M. and Mohamed, Z. I. (2006). Male knowledge, attitudes and family planning practices in Northern Nigeria. *African Journal of Reproductive Health* 10(3): 53-65.
- Food and Agriculture Organization (FAO), (2009). Promoting the Growth and Development of Smallholder Seed Enterprises for Food Security Crops: Best Practices and Options for Decision Making. FAO Plant Production and Protection Paper Case studies from Brazil, Côte d'Ivoire and India. 24pp.
- Food and Agriculture Organization (FAO), (2010). A data portrait of smallholder farmers. A Report Prepared for National Medium Term Priority Framework (NMTPF). Kathmandu, Nepal. 6pp.
- Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), (2016). Food and Agriculture Organization (of the United Nations), Statistics Division. [Available at <http://faostat3.fao.org/>] site visited on 22/06/2018.
- Feder, G., Just, R. E. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. The University of Chicago. *Economic Development and Cultural Change* 33: 255 – 297.
- Fivawo, N. C. and Msolla, S. N. (2011). The diversity of common bean landraces in Tanzania. *Journal of Agriculture. Crop Science Department* 2(1): 337-351.

- Gebeyehu, S., Simane, B. and Kirkby, R. (2006). Genotype x cropping system interaction in climbing bean (*Phaseolus vulgaris* L.) grown as sole crop and in association with maize (*Zea mays* L). *European Journal of Agronomy* 24: 396-403.
- He, X., Cao, H. and Li, F. (2007). Econometric Analysis of the Determinants of Adoption of Rainwater Harvesting and Supplementary Irrigation Technology (RHSIT) in the Semiarid Loess. *Plateau of China* 89(3): 243-250.
- Heckman, J. (1976). "The common structure of statistical models of truncation, sample selection and limited dependent variable and a simple estimator for such models". *The Annals of Economics and Social Measurements* 5: 475-492.
- Heckman, J. (1979). *Sample Selection Bias as a Specification Error*. 47(1): 153-161.
- Hillocks, R. J., Madata, C. S., Chirwa, R., Minja, E. M. and Msolla, S. (2006). Phaselous bean improvement in Tanzania, 1959-2005. *Journal of Agriculture*. Sokoine University of Agriculture. pp. 215-231.
- Ibrahim, M., Florkowski, W. and Shashidhara, K. (2012). The determinants of farmer adoption of improved peanut varieties and their impact on Farm income: Evidence from Northern Ghana. Fort Valley State University. Ghana. 16pp.
- Isham (2002). The effect of social capital on fertilizer adoption: Evidence from rural Tanzania. *Journal of African Economies* 1(1): 39-60.
- Kafle, B. (2010). Determinants of adoption of improved maize varieties in developing countries. *International Research Journal of Applied and Basic Science* 1(1): 1 – 7.

- Kagoungo, W., Ortmann, G. F. and Wale, E. (2012). Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties: Evidence from an extension intervention in Nyanza and Western provinces, Kenya. *African Journal of Agricultural Research* 7(3): 493-503.
- Katungi, E., Karanja, D. and Wozemba, D. (2011). A Cost-Benefit Analysis of Farmer Based Seed Production for Common Bean in Kenya. *Journal of Crop Science* 19 (4): 409-415.
- Katungi, E., Magreta, R. and Letaa, E. (2017). Adoption and Impact of Improved Bean Varieties on Food Security in Malawi. A Technical Report by CIAT-PABRA. 46pp.
- Kinuthia, B. and Mabaya, E. (2017). The Impact of Agricultural Technology Adoption on Farmer Welfare in Uganda and Tanzania. Policy brief working paper. No. 163. 3pp.
- Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. Second Revised Edition ed. 2004: New Age International. 418pp.
- Langyintuo, A. S., Mwangi, W., Diallo, A. O., MacRobert, J., Dixon, J. and Banziger, M. (2008). *An Analysis of Bottlenecks Affecting the Production and Deployment of Maize Seed in Eastern and Southern Africa*. Harare, Zimbabwe, CIMMYT. 112pp.
- Larochelle, C., Asare-Mafaro, D., Birol, E. and Alwang, J. (2016). Assessing the adoption of improved bean varieties in Rwanda and the role of varietal attributes in adoption decisions. Harvesting working paper. No. 25.

- Legese, D. (2004). Agricultural Research and Technology Development in Ethiopia. Proceedings of the workshop help to discuss the socio-economic research results of 1998-2002, Addis Ababa, Ethiopia. EARO, 2004.
- Letaa, E., Kabungo, C., Ojara, M. and Ndunguru, A. (2015). Farm level adoption and spatial diffusion of improved common bean varieties in Southern Highlands of Tanzania. *African Crop Science Journal* 23(3): 261-277.
- Lopez, H. (2010). Adoption of Improved Maize and Common Bean Varieties in Mozambique. Department of Agriculture, Food and Resource Economics. A thesis for Award degree of MSc. in Agricultural, Food and Resource Economics at Michigan State University. 104pp.
- Lowder, S., Scoet, J. and Raney, T. (2016). *The Number, Size and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide*. Food and Agriculture Organization of the United Nations, Rome, Italy. 87: 16-29pp.
- Ministry of Agriculture Food Security and Cooperatives (MAFC) and National Bureau of Statistics (NBS), (2012). Annual Agricultural Sample Survey (Crops and Livestock Report). 109pp.
- Mbugua, F. (2009). An Analysis of Factors Influencing Adoption of The Recommended Maize Technology's Package in Makuyu Division, Murang'a South District, Kenya. Dissertation Award of MSc. Degree at Kenyatta University, Kenya. 113pp.
- Mdoe, N. and Macha, J. (2002). Gender and Rural Poverty in Tanzania: Case of Selected Villages in Morogoro Rural and Kilosa Districts. LADDER working paper No.8. University of East Anglia, Norwich, UK. 10pp.

- Mnenwa, R. and Maliti, E. (2010). A Comparative Analysis of Poverty Incidence in Farming Systems of Tanzania. Special Paper 10/4. Dar es Salaam: REPOA. 37pp.
- Mugenda, O. and Mugenda, A. (2003). *Research Methods Quantitative and Qualitative Approaches*. Nairobi: Acts Press. 182pp.
- Mustapha, S. B., Makinta, A. A., Zongoma, B. A. and Iwan, A. S. (2012). Socio-Economic Factors Affecting Adoption of Soya Bean Production Technologies in Takum Local Government Area of Taraba State, Nigeria. *Asian Journal of Agriculture and Rural Development* 2(2): 271-276.
- Namwata, L., Lwelamira, J. and Mzirai, O. (2010). Adoption of Improved Agricultural Technologies for Irish Potatoes (*Solanum tuberosum*) among Farmers in Mbeya Rural District, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences* 8(1): 927-935.
- National Bureau of Statistics (NBS), (2012). Tanzania National Panel Survey Report Wave 2, 2011. Dar-es-Salaam, NBS.
- Negatu, W. and Parikh, A. (1999). The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru (District) of Ethiopia. *Agricultural Economics* 21: 205-216.
- Ng'eno, E.K. (2017). Dairy farmer households' farm gate milk price heterogeneity in Kericho county, Kenya. *Journal of Development and Agricultural Economics*. Department of Agricultural Economics and Resource Management. Moi University, Kenya 9(7): 168-177.

- Nkonya, E. (2001). Cross-Pollinated Crop Variety Adoption Studies and Seed Recycling: The Case of Maize in Tanzania: *Astern Africa Journal of Rural Development* 17: 25-34.
- Nkonya, E., Xavery, P., Akonaay, H., Mwangi, W., Anandajayasekeram, P., Verkuijl, H., Martella, D. and Moshi, A. (1998). *Adoption of Maize Production Technologies in Northern Tanzania*. International Maize and Wheat Improvement Center, Mexico. 53pp.
- Ogunyemi, A. I. and Ojo, S. O. (2014) Analysis of Factors Influencing the Adoption of Improved Cassava Production Technology in Ekiti State, Nigeria. *International Journal of Agricultural Sciences and Natural Resources* 1(3): 40 - 44.
- Ojeleye, A., Saleh, K. and Oyewole, S. (2014). Non-Farm Income and Food Security Status of Small Scale Farming Households in Nigeria. Department of Agricultural Economics and Rural Sociology. Ahmadu Bello University, Nigeria. *Research Journal of Agriculture and Forestry Sciences* 2(12): 7.
- Ojo, S. O. and Ehinmowo, O.O. (2010). Economic Analysis of Kola-nut Production in Nigeria. *Journal of Social Science* 22(1): 1-5.
- Okorie, O. J. (2012). Level of Adoption of Improved Cassava Varieties and The Profitability of Cassava Production in Enugu state, Nigeria. A Master thesis. Department of Agricultural Economics. University of Nigeria. 84pp.
- Oladeji, O. O., Okoruwa, V. O., Ojehomon, V. E. T., Diagne, A. and Obasoro, O. A. (2015). Determinants of Awareness and Adoption of Improved Rice varieties in North Central, Nigeria. *Rice Genomics and Genetics* 6(7): 1-10.

- PABRA (2015). The Role of CIAT in the Pan-Africa Bean Research Alliance. 25pp.
[[https:// cgspace.cgiar.org/bitstream/handle/10568/ 67075/Review _of_ CIAT_ PABRA_report_01_03_15.pdf;sequence=1](https://cgspace.cgiar.org/bitstream/handle/10568/67075/Review_of_CIAT_PABRA_report_01_03_15.pdf;sequence=1)] site visited on 12/07/2017.
- Raphael, D. (2014). Determinants of Adoption of Early Maturing Maize Varieties in Nzege District, Tabora region. Dissertation Award of MSc. Degree at Sokoine University of Agriculture. Morogoro, Tanzania. 101pp.
- Rogers, E. M. (1995). *Diffusion of Innovation*. Free Press, New York. 518pp.
- Ronner, E. and Giller, K. E. (2013). Background information on agronomy, farming systems and on going projects on grain legumes in Tanzania. Report from N2AFRICA Programme. 140pp.
- Rubyogo, J. C., Gebeyehu, S., Tumsa, K. and Wozemba, D. (2011). Increased bean productivity through increased access to improved seeds and use of improved bean management techniques in Ethiopia. A Report from CIAT-PABRA. pp 1-19.
- Sadiq, M. S. and Yakasai, M. T. (2013). Profitability and production efficiency of small-scale maize production in Niger State, Nigeria. *Journal of Applied Physics* 3(4): 19-23.
- Samboko, P. C. (2011). Assessment of Factors Influencing. The Profitability of Bean Production in Zambia, University of Zambia. pp 1-25.
- SAT (2014). Solutions for a Better Future for Tanzania. Annual Report. 16pp.

- Schumpeter (1960). Construction of a New Theory of Profits. *American Economic Review*, Volume XLI.
- Shalma, H. (2014). Economic Analysis Of Soya Bean Production Under Sasakawa Global 2000 Project in Kaduna State, Nigeria. A Master's Thesis. Department of Agricultural Economics and Rural Sociology. Ahmadu Bello University, Nigeria. 104pp.
- Shampine, A. (1998). Compensating for information externalities in technology diffusion models. *Journal of Agricultural Economics* 80(3): 337-346.
- Sibiko, K. W. (2013). An Analysis of Economic Efficiency in Bean Production: Evidence from Eastern Uganda. *Journal of Economics and Sustainable Development* 14(13).
- Sigei, G., Bett, H. and Kibet, L. (2014). Determinants of Market Participation among Small-scale Pineapple Farmers in Kericho County, MPRA Paper No. 56149. Egerton University, Kenya. 81pp.
- Siri, B. N., Martin, N., Samuel, B. E., Martin, F., Mboussi, M., Celestine, N. and Laurent (2016). Factors Affecting Adoption of Improved Common beans (*Phaseolus vulgaris* L.) Varieties in the Western Highlands of Cameroon. 13pp.
- Smale, M. and Lust, R. (1994). Land allocation in HYV adoption models: an investigation of alternative explanations. *Journal of Agricultural Economics* 76(3): 535-546.

- Teferi, E. T. (2013). Adoption of Improve Sorghum Varieties and Farmers Varietal Trait Preference In: Kobo District, North Wolo Zone, Ethiopia. Degree for Award of a Masters Thesis of Haramaya University. 136pp.
- Tiamiyu, S. A., Akintola, J. O. and Rahji, M. A. J. (2009). Technology Adoption and Productivity Difference among Growers of New Rice for Africa in Savanna Zone of Nigeria. *Journal of Agricultural Economics* 27 (4): 193-197.
- Tiwari, N. (2010). "Economic and Technological Constraints facing farm women", *International Journal of Rural Studies* 17(1): 1-5.
- Tsinigo, E. and Ohene, K. (2016). Varietal adoption and Economics of rice production in Ejura-Sekyedumase and Atebutu-Amantin municipalities in Ghana. University of Science and Technology. Ghana. *Journal of Economics and Sustainable Development* 7(20): 67-78.
- United Republic of Tanzania. (2016). Value Chain Roadmap for Pulses 2016-2020. Working paper. 82pp
- World Bank (2014). Agribusiness Indicators: Tanzania. World Bank, Washington DC.
- World Bank (2016). Africa Development Indicators. World Bank. Washington DC.
- World Bank (2017). Africa Development Indicators, World Bank, Washington DC.
- Xinhua (2016). News. [xinhuanet.com] site visited on 17 November 2016.

APPENDIX

Appendix 1: Farmers Questionnaire

TITLE: FARMERS ADOPTION OF IMPROVED BEAN VARIETIES IN MBEYA

RURAL DISTRICT, TANZANIA

PART A: GENERAL SURVEY INFORMATION

Region.....

District

Ward name.....

Village name.....

PART B: SOCIO-ECONOMIC PROFILE

1. Name of the respondent.....
2. Age of the respondent.....
3. Sex.....
 - a) Male b) Female
4. Education level.....
 - a) Primary b) Secondary c) Other level (specify)
5. Main occupation.....
 - a) Farmer b) Paid employment c) Studying d) other (specify)
6. Total size of farm owned(in acres)
7. Number of crops grown.....(list the crops)

PART C: BEANS PRODUCTION

1. Plot size under beans production.....
2. Aim of engaging in beans production.....
 - a) Consumption purpose

- b) Commercial purpose
- c) Both(consumption and commercial purpose)
- 3. Number of bags of beans harvested last year.....
- 4. Number of bags of beans sold last year.....
- 5. Price of beans harvested sold per bag.....
- 6. Technology used in beans production.....
 - a) Advanced technology
 - b) Local technology
 - c) Both (advanced and local technology)
- 7. Costs associated with beans production
 - Inputs used:
 - i) Farm size.....Cost.....
 - ii) Seed quantity.....Cost.....
 - iii) Number of labourers.....Cost.....
 - iv) If advanced technology was used

Technology used	If yes put a tick	Ownership If hired 01 If owned .02	Cost acquired
Tractor			
Power tiller			
Irrigation equipments			
Weeding, herbicide application			
Combine harvester			

v) If local technology was used

Technology used (Name the local tools used and activities)	Ownership If hired 01 If owned 02	Cost acquired

vi) Means of transportation.....

Ownership.....Cost.....

8. Have you ever used improved bean varieties?.....

a) Yes b) No

9. If yes, for how long have you been using the improved varieties?

.....

10. How many improved varieties do you know?.....

11. How many improved varieties did you use/plant last year?.....

(List the varieties).....

12. If used the improved seeds what is the reason behind this

preference.....

13. What advantages did you obtain by using these improved

seeds.....

14. What was the size of the area planted under the improved

varieties?.....(in acres)

15. If no, what is the reason for not using improved varieties?

16. If no mention the local varieties you used last year.....
17. Experience in own farm activities.....
18. Experience in cultivating beans.....
19. Off-farm income:
- i) Involvement of household in off-farm activities.....(Yes/No)
 - ii) If Yes, mention these activities.....
 - iii) If Yes, how much did you obtain in the last year from the off-farm activities mentioned?
 - iv) Did you use any of the amounts from the off-farm income in beans production during last year?.....
 - v) If Yes, how much did you use for accessing the improved varieties.....
20. Extension services:
- i) Have you ever contacted an extension officer.....(Yes/No)
 - ii) If Yes, how many times.....
 - iii) If yes, did you get any information on improved varieties from extension services?
 - iv) Are you a member of any farmers' organization.....
 - v) If Yes, do you get any access to the improved seeds through the organization.....
21. Credit availability:
- i) Do you have access to credit.....(Yes/No)
 - ii) If Yes, what was the source of credit you obtained.....
 - iii) How much did you obtain.....
 - iv) How much did you use in beans production.....
 - v) How much did you use to access improved seeds.....