THE DETERMINANTS OF ADOPTION OF IMPROVED MAIZE PRODUCTION TECHNOLOGIES AMONG FARM HOUSEHOLDS IN QUTHING, LESOTHO: A GENDER ANALYSIS

SECHABA, RAKOTSOANE

THESIS SUBMITTED TO THE FACULTY OF AGRICULTURE, THE NATIONAL UNIVERSITY OF LESOTHO IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND RESOURCE ECONOMICS

NATIONAL UNIVERSITY OF LESOTHO

ROMA

AUGUST 2022

DECLARATION

I, Sechaba Rakotsoane, declare that this research dissertation is my own work; it was undertaken by me, except where otherwise indicated. It is submitted for the degree of Master of Science in Agricultural and Resource Economics at the National University of Lesotho. It has not been submitted for any other degree at any other university.

Signature …………………………………

Date ………………………………………

CERTIFICATION

We, the undersigned, certify that the work reported herein meets the standards required for thesis for the Degree of Master of Science in Agricultural and Resource Economics.

Name: Dr Brian Muroyiwa

Signature: …………………. Date: …………………………………

Supervisor

Name: Professor Olaniyi, Olumuyiwa Akin.

Signature: …………………… Date: ……………………………………

Internal Examiner

Approved for inclusion in the Library of the National University of Lesotho

Name: …………………………

Signature: …………………………………. Date: …………………………………..

Head of Department of Agricultural Economics and Extension.

Name: ……………………………………………

Signature: …………………… Date: ………………………………….

Dean of the Faculty of Agriculture

DEDICATION

This thesis is dedicated to God Almighty and my adorable family.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, Dr Brian Muroyiwa. This work would not have been accomplished without his enduring support, guidance and unwavering patience.

I would like to extend my gratitude to my wife, Mrs Mapaballo Rakotsoane, for her unwavering support throughout the years.

I would also like to acknowledge my supervisor at work, Mr Thapelo Mothae for all his assistance and continuous encouragement.

I am extremely grateful to my colleagues, Mr Tumelo Manyeli and Mr Khutlang Lekhisa, for the unmatched mental, emotional and spiritual support that helped and carried me to the finish line.

ABSTRACT

Maize is a major staple food in Lesotho, and it constitutes between 50% - 60% of an average household diet. Maize production objectives vary because of characteristics demanded by the market, home consumption and animal feeds. Men tend to prefer high-yielding varieties to potentially sell the surplus. Women, on the other hand, are often interested in maize's culinary, processing, and nutritional qualities; long-term storability and tolerance of the cultivar to shocks, such as climate variability. The main objective of the study was to investigate the gender gap in agricultural productivity with focus on technology adoption of maize farm households in Quthing. The study obtained data from a randomly selected sample of 139 male and female headed households maize crop producers in the study area. The study used descriptive statistics and probit regression for data analysis. The results of the study showed that more male (82.5 %) farmers adopted improved maize production technologies compared to their female counterparts (54.2 %). The factors that influenced adoption of improved maize technologies in the study area were farming experience, confidence in extension skills, membership of farmer group, farmers' training and walking distance to agricultural office. The aforementioned factors are common factors that drive the adoption of improved maize technologies by both male and female farmers; except membership of farmers' group, confidence in extension skills and access to ICT that are specific to male and female farmers respectively. The study recommends that farmers should be encouraged to join and form farmers-based organizations. The study also recommends enhancement of access to information for farmers through extension services creating and producing relevant programmes available through the radio, television and the mobile phone platforms. The public and private extension systems must employ more field extension staff who will train farmers to improve their skills and production techniques. Extensions workers must benefit from capacity building to improve their competencies in supporting farmers in interventions aimed at improving adoption of improved maize production technologies by both male and female farmers in the study area.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

AIS	Agricultural Information Service
CGIAR	Consultative Group on International Agricultural Research
DAR	Department of Agricultural Research
FAO	Food and Agriculture Organization
FBOs	Farmer Based Organizations
ICT	Information and Communication Technologies
MAFS	Ministry of Agriculture and Food Security.
NUL	National University of Lesotho
OPVs	Open-pollinated varieties
RSA	Republic of South Africa
SDC	Swiss Agency for Development and Cooperation
SSA	Sub-Saharan Africa
UISP	Universal input subsidy policy

CHAPTER I

INTRODUCTION

1.1. Background

Agricultural production remains the main source of livelihoods for most rural communities in Lesotho (Rantšo *et al*., 2020). Agriculture provides the main source of food and employment for more than 60% of Basotho in the country (Gwimbi, 2017). Maize is Lesotho's major staple food, and it constitutes between 50% - 60% of an average household diet (kilojoules) in Lesotho (Nhlengethwa et al., 2020). It is produced by all farming households principally for home consumption in the four ecological zones (mountain areas, foothills, lowlands and Senqu river valley). Smallholder farmers are the dominant maize producers, with a few commercial farmers who sell maize grains to two major milling companies Lesotho Milling Company and Lesotho Flour Mill and breweries in the country (Morojele and Sekoli, 2016).

Gender roles are key determinants in the distribution of responsibilities and resources between women and men. On average, women comprise 43 percent of the agricultural labour force in low- and middle-income countries (Quisumbing *et al*., 2014). Among the greatest constraints and that poor women farmers faced are gender stereotypes, social restrictions, and lack of information concerning value chains (Tanumihardjo *et al.,* 2020). Women's empowerment is important to ensure their participation in agriculture, access and control of resources, and adoption of new agricultural technologies (Ruel *et al*., 2018). One way to address gender and social inclusion is to evaluate agriculture as a social practice because gender roles are not fixed, but are changeable and shaped by ideology, religion, ethnicity, education, culture, and tradition (Swiss Agency for Development and Cooperation [SDC], 2015). Gender analysis provides a basis for robust inquiry of the different roles that women and men play in a farming system (SDC, 2015).

Gender stereotypes and social restrictions influence women's roles and livelihoods in agro-food systems, especially their willingness to adopt new varieties of maize for food preparation (Gunaratna et al., 2016). While both male and female farmers value grain yield and stress resilience, several studies shows that women and men have different preferences for certain varieties of maize and their corresponding agronomic and consumer characteristics (Christinck *et* *al*., 2017). The intended maize production objectives vary because of characteristics demanded by the market, home consumption, and animal feeds. Men tend to prefer high-yielding varieties to potentially sell surplus (Christinck *et al*., 2017). Women, on the other hand, are often interested in maize's culinary, processing, and nutritional qualities; long-term storability; and vulnerability to shocks, such as climate variability and depletion of the natural resource base. Thus, gender-sensitive breeding approaches are necessary to ensure new varieties, fulfil the demands of the production system from farmers to end-users. While women provide labour, in many populations where maize is a staple, they may have less control over decision-making on agricultural practices, technology adoption, marketing, and income (O'Brien *et al*., 2016). Agricultural information is important to women even though they are not the final decision makers on which seed, fertilizer, or other inputs to purchase (Christinck *et al*., 2017). Women also may have less quality contact with agricultural extension services (O'Brien *et al*., 2016), and often limited in time due to other family responsibilities, they may not participate in research and extension programs, farmers participatory experiments, demonstrations, and field days. In many cultures and traditions, women are the custodians of the family diets, which influence their priorities towards selecting varieties that are palatable and nutritious for their children (Tanumihardjo, 2017).

1.2 Statement of the Problem

The economy of Lesotho is mostly dependent on agriculture. The type of agriculture practiced is mainly subsistence with a few farmers practicing commercial farming. Grain production is a common enterprise in Lesotho, with more than 75% of the cropland devoted to maize (*Zea mays*) and wheat (*Triticum aestivum*) production (Masupha *et al*., 2018). However, while both male and female farmers are involved in maize production, little is known about gender differences in the adoption of technologies with regard to improved maize productivity. Low productivity of maize, whose measurement is by the value of agricultural produce per unit of cultivated land, remains a challenge. Limited access to improved technologies by women compared to their male counterparts is one of the critical constraints to increasing production and productivity of maize on women-led farmlands (Gebre *et al*., 2019). Women farmers also have low production on their plots, and this is attributed to women having less access to and control of resources compared their male counterparts (Doss, 2018). Huyer (2016) highlighted that women’s agricultural available farm implements are traditionally based, labour-intensive and thus, they tend to miss receiving adequate attention in technology support programs, particularly those for land preparation and weeding. Farm implements that are available tend to be oriented towards men's physique or activities and will often be too heavy or culturally inappropriate for women to use them comfortably (Wei *et al.*, 2021).

1.3 Objectives

The main objective of the study was to investigate the gender gap in agricultural productivity and production with focus on technology adoption of maize farm households in Quthing, Lesotho.

The specific objectives of the study are to:

1. Describe the socio-economic and institutional characteristics of male and female farmers in the study area.
2. Determine the adoption rates for male and female farmers of improved maize production technologies in the study area.
3. Determine the factors influencing the adoption of improved maize production technologies.

1.4. Significance of the Study

Women face gender-based challenges in the agricultural sector, applying a gender lens in the maize value chain can be of great importance to gain insight into constraints and opportunities for improvement. The findings of the study might assist the Ministry of Agriculture and Food Security through the Department of Field Services, in the development of the agricultural policy, aimed at closing the gender gap by providing equal opportunities and access to productive resources for men and women farmers to increase their maize productivity. This study is imperative in providing information that might be helpful in designing programmes that are gender responsive thereby contributing to overall agricultural development and poverty alleviation in Lesotho.

1.5 Limitations of the Study

The study relies on production data from a single crop to measure gender differences in agricultural productivity, while gender differences in agricultural production are based on aggregate crop production and vary across various commodities as well as over agricultural production years

1.6 Delimitations of the study

Delimitations of the study are those characteristics that limit the scope and define the boundaries of the research (Theofanidis and Fountouki, 2018). Due to lack of the financial resources the study did not cover all areas in Quthing, but it will focus only on farmers within Mount Moorosi villages.

1.7 Layout of the thesis

The study is organized into five chapters. It starts with the introduction, which includes statement of the problem, objectives, significance of the study, limitations and delimitations of the study. The second chapter reviews literature that deals with past studies and information pertinent to the study. The third chapter explains research methodology including description of the study area, sampling techniques, methods of data collection and tools for data analysis. In the fourth chapter the main findings of the study are discussed. Finally, conclusions and recommendations are provided in chapter five.

CHAPTER II

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter gives theoretical highlights for the study. It is organized into sub topics such as measuring gender differences in agricultural productivity, maize varieties in Lesotho, gender differences in access to and adoption of improved maize value chain technologies, women empowerment in agriculture and agricultural productivity, gender differences in technology adoption, factors influencing adoption of improved maize production technologies and the conceptual framework that illustrates the relationship between the dependent, independent and intervening variables.

2.2. Measuring gender differences in agricultural productivity

A substantial body of the existing studies pointed out that gender inequality in access to productive resources such as land, improved varieties, fertilizers, farm equipment, labour, training, and information lead to the difference in agricultural productivity between male and female farm households. However, the extent of the differences and the relative importance of their potential drivers depend on the country or region, the sample size, the type of crop, the unit of measurement, or the method of analysis. To measure the amount of agricultural productivity differentials and unpack their potential sources, the frequently used approaches by existing studies are production function estimates (Ragasa *et al*. 2012; Challa and Mahendran 2015) Production function estimates measure the differentials by coefficients. Some studies use switching regression in a counterfactual manner to measure production efficiency and test whether the difference is driven by the differences in observable characteristics or return to these characteristics (Gebre, 2021).

Concerning the measurement of agricultural productivity using the sex dummy, the commonly used approaches by existing studies consider the sex of the household head, the sex of the farmer, and the sex of the landowner or decision maker. The headship is the most widely used approach by many studies; however, it does not consider the contribution of women in a male-headed household and men in a female-headed household (Doss, 2018). The approach to using the gender of the farmer or landowner may be adopted to determine the productivity difference between men and women within the same household; however, this approach is also problematic if farmers are misidentified in the household. In some cultural contexts, women are considered helpers for men working on the farm, but not as farmers because they spend more time working in the homestead (Gebre, 2021). Ragasa *et al*. (2012) noted that women as farmers are not always reached by extension service. One study was completed in western Africa, where men and women have control on separate plots; meanwhile, this practice is much less common in eastern Africa. Even studies based on the sex of the landowner in the east African region show a significant overlap along gender lines. For instance, in their study, De la O Campos *et al.* (2016) used nationally representative data from Uganda and found that 92% of female-held plots and 77% of female-managed plots belong to female-headed households. In addition, in southern Ethiopia, particularly in the Dawuro Zone, household headship is closely related to the occupational status as farmer because land entitlement always belongs to the heads "Who becomes a household head is then a matter of concern?". In this regard, the existing social norms allow significant gender biases in favour of men.

Men typically inherit property rights of land and other household assets of the household, which leads them to become the household head. Women are normally supposed to be a household head only in the absence of their husband due to the death, divorce, seasonal migration for wage work, or disappearance. Women in male-headed households normally have no separate plot for themselves while women in female-headed households own plots provided by their husband or inherited from their husband in accordance with the culture and traditions in Southern Ethiopia. Considering these circumstances some studies use the gender of the headship to compare gender differences in maize productivity. Regarding the unit of productivity measurement, the yield (quantity of output per unit area) and the value of output per unit of land are the most used approach by the existing studies. Yield measurement is simple and works best when farmers grow a single crop on a plot; however, it is less straightforward when farmers grow numerous crops on a single plot of land at the same time (Gebre, 2021). When one is interested in evaluating the productivity of a single crop across different periods, using the yield method is problematic for the plots where multiple crops are grown across different seasons. Even for a single production season, it is difficult to measure the yield of crops that are continuously harvested (Doss 2018). In Lesotho, maize-growing farmers harvest some portion of their maize during the growing season, at the green stage particularly for their family consumption and selling to vendors. The majority is harvested at the peak maturity (grain) stage (Morojele and Sekoli, 2016). In addition, some farm households apply intercropping practices on their maize plots. These factors raise complexities for yield analysis (Doss 2018).

Previous studies commonly use the value of output, summing the value of individual crops as a measure of farm productivity, especially when more than one crop is grown on a plot (Gebre, 2012). Doss (2018) emphasized that if one is interested in measuring the productivity of individual crops on the intercropped plots, he/she can allocate a unit area of land for the crop grown to its respective output. For example, if a hectare of the plot is intercropped equally with maize and legumes, then maize is grown on half a hectare and legumes on another half a hectare, with the quantity of the output per hectare of each crop calculated accordingly. Using the market value of output as the measure of productivity is conceptually clearer and solves the limitations of the yield method; however, it is also problematic if a given quantity of outputs of the same product receives dissimilar prices across different seasons or between different village markets.

The common approach to compute the value of each crop applied by the existing studies is to use village-level median prices based on farm household self-reported sales information. Arthi *et al*. (2016) noted that the existing studies used different units to gauge the contribution of different factors impacting gender differences in agricultural productivity. Among those factors, the most difficult to measure in the context of developing countries is labour, which is the most important input in the production process. Because smallholder farms in developing countries typically employ family labour, there is no wage income or written records of labour time to estimate the family labour input. This situation is particularly applicable in Ethiopia. In most of the previous studies, farmers were asked to recall the amount of labour used for their plot for the previous farming season (Doss, 2018). This leads to biases in reporting on labour time and affects the quality of data collected in the developing country (Arthi *et al.*, 2016). The farming activities are not as regular as other office works, and many of these activities are carried out jointly with other household activities (Doss, 2018). The seminal work by Arthi et al. (2016) points out that the biases in farm labour data are derived from reports on the weeks and days worked, not from the hours worked per day. This is because some farmers or family members will work longer hours per day than some other farmers or family members. As a result, a day labourer could have a different marginal contribution to farm output (Doss, 2018). Since male and female labour is not substitutive in agriculture (Gebre, 2021) most of the existing studies have separately estimated the labour inputs of men and women. Some of these studies (Njuki *et al*. 2006; Challa and Mahendran, 2015) estimated the marginal productivity of family labour using shadow wage rates, which represent the opportunity cost of the family labour time (Sharma, 2013).

2.3 Maize varieties in Lesotho

The improved maize varieties are classified into hybrids and open-pollinated varieties (OPVs). Hybrids have the highest yield but are more costly to adopt as the restoration of hybrid vigour requires the purchase of new seeds in each cropping season. OPVs generally have a lower yield than hybrids, but OPV seeds cost less than hybrids and can be recycled for up to three seasons without a significant yield loss (Consultative Group on International Agricultural Research [CGIAR], 2014). In Lesotho, the formal seed sub sector is not well developed as it is dominated by imports from neighbouring Republic of South Africa (RSA). Few quantities are also imported from Zimbabwe and Zambia (FAO, 2016). The two open pollinated varieties under production that have newly been introduced to farmers in Lesotho because of their ability to tolerate drought are ZM 521 and ZM 523. They differ in maturity by 20 days with ZM 523 maturing later (Mofolo, 2021). They are produced in Berea and Leribe districts. The seed growers work under the supervision of department of agricultural research (DAR) from planting, harvesting, grading and packaging (FAO, 2016).

2.4.0 Gender Difference in Access to and Adoption of Improved Maize Value Chain Technologies

2.4.1 Improved Maize Varieties and Fertilizers

Although both men and women benefit from improved technology availability, men tend to benefit more (Aregu *et al.,* 2011). Evidence constantly suggests that male farmers adopt new agricultural production technologies faster than women farmers (FAO, 2014). According to Sinyolo (2020), several studies in Sub-Saharan Africa (SSA) have highlighted the importance of the development and dissemination of productivity-enhancing technological innovations such as improved seed varieties and fertilizers in improving maize productivity among maize farmers.

However, the adoption levels of the innovations by male and female maize farmers in SSA remain low (Meijer *et al.,* 2015). The cost of these technological innovations are high and the liquidity-constrained maize farmers cannot afford them (Sinyolo, 2020). Also, the success of these innovations is not certain, as most succeed under stringent managerial regimes and agro-climatic conditions which are beyond the reach of maize farmers (Gatzweiler and Von Braum, 2016). Improved maize varieties produce higher yields under conditions of adequate moisture and good soil and pest management practices and maize farmers generally farm in circumstances where these conditions are rarely met (Smale and Mason, 2014). Additionally, limited market access, inadequate storage and transport infrastructure reduce the incentive of both male and female maize farmers to invest in the modern technologies (Das et al., 2019). Consequently, these poor farming households generally experience low maize production and or productivity levels and often, total crop failure, leading to poverty and increased vulnerability to food shortage (Hendriks, 2014).

Male and female maize farmers and resource constrained households in Lesotho have been consistently obtaining low yields from maize, and that adversely affected food production as well as considerably reducing income (Molatoli and Li, 2016). To mitigate the situation by improving the welfare of rural households and spurring maize production, the Government of Lesotho endorsed universal input subsidy policy (UISP) on improved maize varieties and fertilizers and other inputs such as herbicides and pesticides from 2001/02 after food security emergency was declared (Schwab and Porter, 2009). Mohlatsane et al. (2009) discovered that even though the government provides subsidies, subsistence farmers still do not afford improved maize varieties and fertilizers costs as the commercial banks find it risky to give them credit. There are also views that, targeting input subsidies to the poor and smallholder farmers is potentially more efficient than universal as targeted subsidy is directed to different needs of farmers instead of universal subsidies which might not be a response or address needs of maize farmers (Houssou and Manfred, 2011).

2.4.2 Information and Communication Technologies (ICT)

Adoption of improved agricultural technologies is fundamental to transformation of sustainable farming system, and a driving force for increasing agricultural productivity (Obayelu et al., 2016). Access to ICT can help maize farmers, traditional and new ICT have played a major role in diffusing information to rural communities and now have much more potential (Munyua, 2000). Rao (2007) noted that ICT can accelerate agricultural development by facilitating knowledge. Farmers can take full advantage of ICT to enhance productivity and generate more income by adopting new technologies, including new improved maize varieties, adding value and marketing their products. Timely access to market information via communication networks also helps farmers make well decisions about what maize variety to plant and where to sell their produce and buy inputs (Musikoyo, 2012). The adoption of modern industrial inputs in agricultural production relies on the information and communication infrastructure (Lio and Liu, 2006).

Several researchers agrees that to improve agricultural production in Lesotho, male and female farmers must make their own decisions, understand agricultural issues clearly and answer questions related to agricultural production (Mokotjo and Kalusopa, 2010). To achieve this, farmers must be linked with appropriate information and in appropriate format that will help them resolve their information needs and thereby boast production (Mokotjo, 2009). According to Agricultural Information System (AIS) Annual report (2004), the agricultural information service in Lesotho was established under the Department of Field Services of the Ministry of Agriculture and Food Security (MAFS). The Agricultural Information Service (AIS) has two main functions: Firstly, disseminating agricultural Information to support agricultural development and secondly, serving as public relations unit of the MAFS. The division produces agricultural information posters, newsletters, video lessons, magazines, colour slides, field campaigns, and farm radio broadcast, news articles for broadcast over Lesotho National Broadcasting Services (AIS Annual Report, 2004). Mokotjo and Kalusopa (2010) acknowledged the following as the AIS information goals:

- To provide agricultural information needed by male and female farmers for their empowerment in the agricultural production.
- To create awareness on important agricultural-related programs and issues so that clients can make informed decisions.
- Appropriate media/channel of agricultural information dissemination
- Awareness of information service.
- To improve knowledge and skills of stakeholders to optimize agricultural production.

2.5.0. Women empowerment in agriculture and agricultural productivity

In many economies in sub-Saharan Africa (SSA), women provide most of the labour force for agricultural production (Folbre, 2013). Despite women's important role in the agricultural sector, however, empirical evidence shows that they lag men regarding agricultural productivity in SSA due to the gender gap that persist in respect of access to, control over and utilization of productive resources such as land, livestock, labour, education, extension and financial services, and technology (Zereyesus, 2017). Gender inequality in landholding is especially severe in SSA. Cultural norms and traditions restrict women's ability to inherit land and contribute to widening gender gaps in the quality and size of owned farmland (Manda *et al*., 2014). Majority of women are not able to own land or access financial services which means they cannot use their plots to secure loans and invest in improvements such as irrigation and machinery (Paramaiah, 2021). Other gender inequalities evident for women in SSA agricultural sector include limited access to labour and agricultural markets and less control over revenue from agricultural production than men (Moyo, 2016). In addition, women farmers spend more time in domestic work than their male counterparts which can limit their access to productive resources such as extension and advisory services and participation in income generating activities (Diiro, 2018).

Reducing gender inequality is widely recognized around the world as contributing to agricultural growth and attainment of food security (World Bank, 2014). International programmes such as United States Agency International Development which also operates in Lesotho, recognize women's empowerment as a crucial factor in closing gender gaps in agricultural productivity (Zereyesus, 2017). According to Ross *et al.* (2015), empowering women can lead to improvements in their status both inside and outside the household including greater control over household resources, better mental health, and increased access to financial services, skills, development, and income generating opportunities, information about markets and legal rights, all which in turn, positively impact agricultural productivity and food security.

Hence, promoting gender equality is a major focus of rural development policy that aims to achieve sustained food security and poverty alleviation in agrarian economies, including those in SSA (Akpan, 2015). With specific respect to SSA, understanding the role of women's empowerment in agriculture is important for policymakers and development partners interested in devising more effective interventions to increase agricultural productivity enhance household and national economic growth, achieve food security, improve nutrition, and reduce poverty (Manda et al., 2014).

Women in Lesotho make up most of the agricultural labour force and contribute substantially towards sustainable livelihoods and economic development of the country in addition to their traditional domestic responsibilities (Paramaiah, 2021). Lesotho has begun recognizing women as potential agents of sustainable development both in their households and the economy by giving them ownership and control over land in their own capacity whether married or not married. Women in Lesotho are participating in the economy as entrepreneurs using land allocated to them (Motsa, 2014). Although there is new development in relation to women empowerment in Lesotho, women still face some limitations in maize production. Women farmers have little or no capacity to absorb major economic shocks as their productive capacity and productive asset base is considerably smaller compared to that of male farmers. Furthermore, women lack control over decision-making, have less access to modern technologies, credits and incomes compared to men; a situation, which results in gender inequalities (Lesotho Country Analysis Report, 2017).

2.6.0 Gender Differences in Agricultural Technology Adoption

Several studies have examined differences in agricultural technology adoption between males and females. Empirical evidence shows that differences in adoption between male and female farmers are because of unequal access to productive resources (land, credit, education) and access to critical resources including extension services that are fundamental for agricultural productivity
(Ragasa *et al.,* 2012). However, other empirical studies argued that it is not the ease of access to inputs but the tendency to utilize inputs that limit many women farmers in technology adoption (Peterman *et al*., 2010).

Modern studies of technology adoption enumerated those disparities in productivity between male and female being caused by the difference in resources and sometimes return from those resources (Aguilar *et al*., 2014). It is not that women are poorer farmers other than men just because of limited access to and control over resources which leads them to have low productivity (Croppenstedt *et al.,* 2013). The study by Herell and Krishnan (2007) found no productivity differences between male and female-headed households in Zimbabwe. The reason behind this is that the productivity gap between male and female farmers diminishes once there is equality in input use between them (Oseni, 2015). It is, however, important to consider the gender gap in the level and intensity of adoption of improved maize varieties as a gender gap in productivity and food security in male and female-headed households, which have received little attention, despite a large body of literature on the gender gap in technology adoption and productivity.

Given the gender division of labour in many African rural societies, women tend to have limited economic opportunities because they bear nearly all task in the household including taking care of children and other family members; tasks which men are likely not to do. For example, women spent a large amount of their time, about 85 to 90 percent of household tasks such as searching for and collecting water and firewood and food preparation (Huyer, 2016). This increased labour and time demand on women and the need to stay at home to perform these tasks reduces the likelihood that they will participate in different income earning opportunities in the global, including agricultural production. This has great implications on technology adoption as well as food security in households. Therefore, to realize the contribution of women in food security and poverty reduction, it is necessary to empower women in decision making in agriculture as well as closing the gender gap in the level and intensity in technology adoption.

2.7.0 Technology adoption

Different authors define technology in different ways. Loevinsohn *et al.* (2013) defines technology as the means and methods of producing goods and services, including methods of organization as well as physical technique. According to these authors new technology is new to a particular place or group of farmers or represents a new use of technology that is already in use within a particular place or amongst a group of farmers. Technology is the knowledge or information that permits some farm duties to be accomplished more easily, some service to be rendered or the manufacture of a product (Lavison, 2013). Technology itself is aimed at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of the technology hence it helps save time and labour (Mwangi, 2015).

Adoption is defined in different ways by various authors. Loevinsohn *et al*. (2013) defines adoption as the integration of a new technology into existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation. Masimba *et al*. (2021) defines adoption as a mental process an individual passes from first hearing about an innovation to final utilization of it. Adoption can be described through rate of adoption and intensity of adoption. The former is the relative speed with which farmers adopt an innovation and it has as one of its pillars, the element of 'time'. On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Mwangi *et al.*, 2015).

2.8.0 Factors influencing adoption of improved maize production technologies

2.8.1. Age of the household head

Age is assumed to be a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Kariyasa and Dewi, 2011). On contrary age has been found to have a negative relationship with adoption of technology. This relationship is explained by Mwangi (2015) that as farmers grow older, there is an increase in risk aversion and a decreased interest in long term investment in the farm. On the other hand, younger farmers are typically less risk-averse and are more willing to try new technologies.

2.8.2. Gender

Mostly cultural factors matter when it is seen from gender point of view. Most agricultural input decisions are influenced by decision of the male household heads. Hence it is expected to affect the adoption decision of farm households (FAO, 2011). Gender affects technology adoption since the head of the household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms (Mignouna *et al*., 2011).

2.8.3. Education level of the households

It is well expected that farmers with more education are aware of more information and be more efficient in evaluating and interpreting information about innovations than those with less education. Thus, it is hypothesized that producers with more education are more likely to be adopters than farmers with less education. It is measured by number of years of schooling of the head of the households (Challa, 2014). Gaya *et al.* (2017) noted that acquiring high level of education result in a positive adoption of technology and provide knowledge and skills needed to understand technology.

2.8.4. Family size and household size

Family size indicates the number of people living in the house of the farmers. It is expected that as the size of the household increase the adoption of new technology increase if number of dependent family members in a household is less. This indicates the family with large number is more involved in adopting the new technology during their farm production effort (Liberio, 2012,). Akpan *et al*. (2012) emphasized that an increase in the household size would increase the family expenditure and probably reduce farm expenditures. On contrary, Tanellari *et al*. (2014) confirmed that female-headed households are more likely to adopt a new technology if there are more people living in the household. This could be an indication of the availability of additional labour, as some improved technologies are generally more labour intensive.

2.8.5. Farming experiences

It is measured in the number of years since a respondent started farming on his own. Experience of the farmers is likely to have a range of influences on adoption. Experience expected to improve farmer's involvement in seed production. Farmers with higher number of years of experience appear to have full information and better knowledge and were able to evaluate the advantage of the technology. Hence it was hypothesized to affect adoption positively (Challa, 2014). The number of years in farming is thought to affect adoption behaviour as it is assumed that adoption of one technology predisposes the farmer to adopt other technologies (Annor, 2013).

2.8.6. Access to credit and off-farm income

The adoption of new technology with complementary inputs requires considerable amount of capital for purchase of modern agricultural inputs such as fertilizers and improved seeds. Farmers who have access to formal credit are more likely to adopt improved technology than those who have no access to formal credit (Akudugu *et al*., 2012). Off-farm income and credit access can support production activities for smallholder households. This does not always hold, however, because higher incomes from off-farm work and credit sources could change the interests of the household and they may want to divert resources away from farming activities. Hence, these variables are expected to have either positive or negative effects on adoption of improved maize technologies (Gebre *et al*., 2019).

2.8.7. Extension service, distance to extension office and confidence in the extension officers' skill

Extension service will help the farm households to understand the importance of the modern technology and enhance the accuracy of implementation of the technology packages. More frequent visits, using different extension teaching methods like attending demonstrations and field day can help the farmers to adopt a new technology. If the farmers get better extension services, they are expected to adopt seed production technologies than others (Akudugu *et al.*, 2012). The agricultural office serves as proxy for access to agricultural extension agents. Access to extension agents will increase farmers' awareness and access to information on the importance of technology adoption (Akpan *et al*., 2012). Shorter distances to extension services may help farmers to have better access to extension officers who have information about improved production technologies which positively affects the adoption decision. Longer distances negatively affect the adoption decision (Kassie *et al*., 2015). Confidence in the skills of extension workers increases the rate of adoption. Improving the quality of the extension workers through, for example, upgrading their skills and increasing their acceptance by the farmers will speed up the adoption process (Beyene *et al.*, 2015).

2.8.8. Farm size

It affects the technology adoption positively as the farmer with larger farm size tries to use the technology in abundant amount for efficiency issues. It is measured in hectares and acres (Saleem *et al*., 2011). Some studies have also reported a positive relation between farm size and adoption of agricultural technology (Uaiene *et al*., 2009; Mignouna *et al*, 2011). Farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size (Uaiene *et al.*, 2009). In addition, lumpy technologies such as mechanized equipment or animal traction require economies of size to ensure profitability (Mwangi, 2015). Some studies have shown a negative influence of farm size on adoption of new agricultural technology. Small farm size may provide an incentive to adopt a technology especially in the case of an input-intensive innovation such as a labour-intensive or land-saving technology. Farmers with small land may adopt land-saving technologies such as greenhouse technology, zero grazing among others as an alternative to increased agricultural production (Mwangi, 2015).

2.8.9. Awareness

Acquisition of information about a new technology is another factor that determines adoption of technology. It enables farmers to learn the existence as well as the effective use of technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Mwangi, 2015). However, access to information about a technology does not necessarily mean it will be adopted by all farmers. This simply implies that farmers may perceive the technology and subjectively evaluate it differently than scientists (Uaiene *et al*., 2009). Access to information may also result to dis-adoption of the technology. For instance, where experience within the general population about a specific technology is limited, more information induces negative attitudes towards its adoption, probably because more information exposes an even bigger information vacuum hence increasing the risk associated with it. It is therefore important to ensure the information is reliable, consistent and accurate. Farmers need to know the existence of technology, its beneficial, and its usage for them to adopt it (Mwangi, 2015).

2.8.10. Farmer training

Training is the process that involves acquisition of knowledge, information transfer, concepts and behavioural change to improve the aptitude and performance of the farmers. Training is a learning process and experience; it seeks a relatively permanent change on farmer's behaviour and improves their job performance. Thus, training involves changing skills, knowledge, attitudes or behaviour (Kumar *et al*., 2005). Henry *et al.* (2012) emphasized that access to farmer training increases participation in improved technology. Participation in farmer training programmes is hypothesized to influence the adoption positively as it facilitates the uptake of new technologies (Abdoulaye *et al*., 2014).

2.8.11. Farmer group

Membership in associations such as cooperative societies has been found to enhance the interaction and cross-fertilization of ideas among farmers (Abdoulaye). Membership of a farmer group is necessary because most of agricultural technologies are usually disseminated through the farmer-based organisation (Wongnaa *et al*., 2018). Danso-Abbeam *et al.* (2017) emphasized that membership of farmer-based organizations is an essential source of information. Farmers get a lot of information regarding production and marketing through a farmer-to-farmer network. Farmers who are not members of associations are expected to have lower probabilities of adoption and a lower level of use of improved maize technologies.

2.8.11. Access to ICT

ICT facilities such as radio, television and mobile phones provide agricultural information on agricultural techniques, commodity price and weather forecast to the farmers (Hopestone, 2014). ICT reduces the transport costs of disseminating agricultural information to the farmers. ICT is systematically associated with adoption of improved maize technologies since farmers who are better informed about improved agricultural technologies have better chances of adopting agricultural technologies than farmers who are relatively less informed (Mottaleb *et al.*,2018).

2.9 Conceptual framework

Conceptual framework represents the researcher's synthesis of the literature on how to explain a phenomenon (Regoniel, 2015). It shows succinctly how the dependent, independent and intervening variables relate with each other to drive the research for a worthwhile result to be achieved. In the framework (Figure 1) the socio economic, technical and institutional factors influence maize production and productivity. They are described in relation to four factors of maize production (Land, labour, capital and entrepreneur). The farmer acts as an entrepreneur in incorporating the other three factors (land, labour and capital). Land is described by land size. Labour is represented by household's size with educational background, age and skills acquired from the extension contact. Capital is described by irrigation and fertilizer application equipment. For a farmer to decide to adopt the improved technology he is determined by the socioeconomic, technical and institutional factors (Mwangi, 2015). Improved technology adoption influences the level of productivity and production. The intervening variables such as market access, women empowerment, storage facility and transport infrastructure indirectly influence the productivity and production of maize.

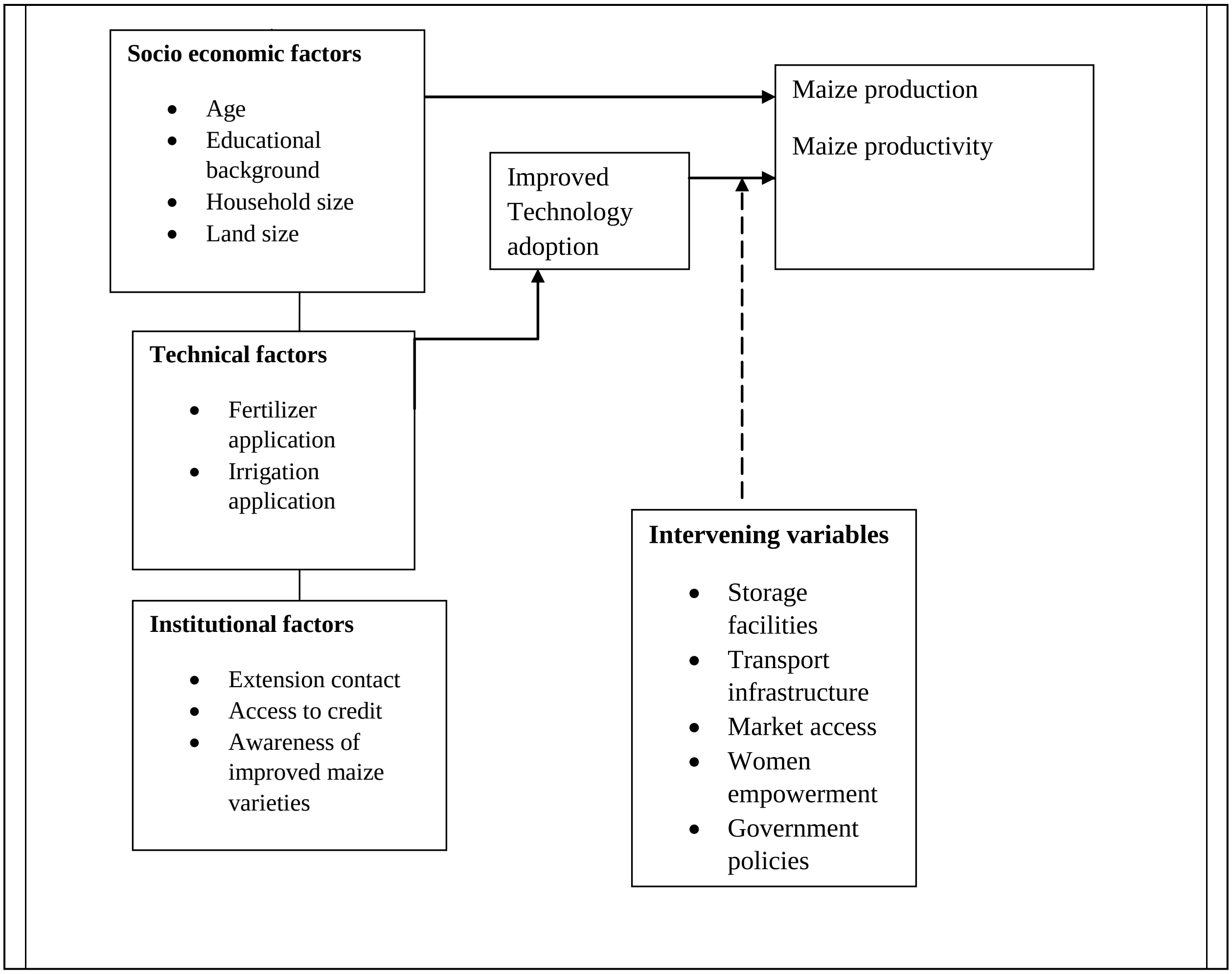

Figure 2.1: Conceptual Framework

2.10. Summary of the chapter

This chapter commenced by unpacking different approaches of measuring the amount of agricultural productivity. The maize varieties produced in Lesotho, which include ZM 521 and ZM 523 and gender difference in adoption of improved maize varieties, fertilizers and ICT were discussed. The literature on women empowerment in agricultural productivity, in which evidence shows that women empowerment can lead to improvements including greater control to resources and better access to finance by women was reviewed. The chapter concluded with factors that influence adoption of improved maize production technologies which include age of the household head, gender, education level of the farmer, distance to agricultural office, family size and household size, farming experience, access to credit, farm income, extension service, farm size, awareness and farmer training, and the inter relationship between the variables in a conceptual frame work.

CHAPTER III

3.0. METHODOLOGY

3.1. Introduction

This chapter provides a description of how the research was carried out. It consists of the study area, research design, population of the study, sampling procedure and sample size, instrumentation, validity, reliability, data collection procedure and data analysis

3.2. Description of the study area

The study was conducted at Quthing district which is in the south of Lesotho. Quthing is Lesotho's southernmost town, about 180 kilometres south of the capital Maseru (Letsie, 2015). Quthing covers approximately 2,916 km² of land with a population density of 73.4 and a population of 115,469 as at 2016. The livelihood of people in Quthing depends on agriculture with 5623 ha of cropland (in 2017/2018) devoted to maize production. The tonnage of maize produced was 1708 metric tons in 2017/2018 cropping season (Bureau of Statistics, 2019).

3.3. Research design

Research design is a framework of methods and techniques chosen by the researcher to combine various components of research in a logical manner so that the research problem is efficiently handled. It provides insights on how to conduct research using a particular methodology (Creswell, 2014). The study used quantitative research design utilizing data obtained in a cross-sectional manner. Cross-sectional data collection focuses on gathering data of variables at one given point of time across a sample (Kesmodel, 2018). Quantitative design can be used to quantify the problem by way of generating numerical data that can be transformed into usable statistics (Gondwe, 2020),

3.4. Population of the study

The target population is defined as the total number of people, groups, elements, or systems that the study focuses on and to whom or which the research findings are to be applied (Fricker, 2012). The study population was made up of 1265 male and female household head farmers producing maize crop in Mount Moorosi villages distributed as follows: Lefikeng (109), Ha Koali (374), Moeling (229), Ha Sekhonyana (273), Maputsoe (125) and Ha Moqalo (155)

3.5. Sampling procedure and sample size

A sample is a group of subjects selected from a population. If the subjects of the same sample are properly selected, most of the time they should possess the same characteristics as the subjects in the population (Bluman, 2012). The main purpose of sampling elements of a population is to draw inferences about the large population based on the information obtained from a sample (Alvi, 2016). The study adopted probability sampling technique to select respondents**.** In probability sampling, every item in the population has equal chance of being included in the sample. It has the greatest freedom from bias but may represent the costliest sample in terms of time and energy for a given level of sampling error (Taherdoost, 2016).

The study used simple random sampling to select farmers who constituted the sample for this study. In simple random sampling, every individual has an equal chance of being selected in the sample from the population. Data is chosen using random number table or computer-generated list of random numbers. It can also be done by lottery method and using currency notes (Acharya *et al*., 2013) The extension officers at Koali Agricultural resource centre at Mount Moorosi assisted the researcher with the list of names of the maize growers in each village and the researcher was able to construct a sampling frame. Based on the required sample size calculated using Nassiuma (2000) formulae, the researcher randomly picked the names of the farmers who were interviewed.

3.5.1 Sample size

According to Noordzi *et al.* (2011), sample size is the total number of experimental units or elements in a study. To decide on the sample size that achieves the objectives of the study, Daniel (2012) indicated that the researcher must carefully assess all the relevant factors but should not waste time and money by selecting a sample size too large or fail to satisfy the objective of one’s study because the sample is too small. The Nassiuma (2000) formula was used to determine the sample size. The overall population from the 6 different villages in Mount Moorosi villages formed the target population of the study.

$$n = \frac{\mathrm{NC}^2}{\mathrm{C}^2 + (\mathrm{N} - 1)e^2}$$

Where: *n* = sample size.

N = target population size.

C = coefficient of variation

e = Standard error

C=25% is acceptable according to Nassiuma (2000), e = 0.02 and N= 1265

$$139 = \frac{1265 \times 0.25^2}{0.25^2 + (1265 - 1) \times 0.02^2}$$

The study sample was made up of 139 farmers as calculated using the sample size formulae and this sample comprises of 80 male headed households and 59 female headed households from six villages in Quthing using the population proportions represented by each village. Using proportional sampling each village contributed to the overall sample based on the ratio of the village population size to the overall population in the six villages. The study multiplied the population proportion of each village by the total sample size required for the study to establish the number of participants/respondents from each village. Based on the foregoing, Table 1 displays the study area's sampled villages, population size, village proportions, and village sample size, while Table 2 provides the gender sample size obtained from each village.

Table 3.1: Village population proportions and village sample size

Village	Population size	Population proportion	Sample size
Lefikeng	109	0.086	12
Ha Koali	374	0.296	41
Moeling	229	0.181	25
Sekhonyana	273	0.216	30
Maputsoe	125	0.099	14
Moqalo	155	0.123	17
Total	**1265**		**139**

Table 2 shows that 58% of the samples where male respondents while 42% were female respondents. The table also shows the distribution of the sample proportion for each gender per village. In most of the villages there were more male respondents compared to female respondents.

Table 3.2: Distribution gender of the respondents per village

Villages	Sample Size	Male farmers		Female farmers	
		Population Proportion	Sample size	Population proportion	Sample size
Lefikeng	12	0.58	7	0.42	5
Ha Koali	41	0.59	24	0.41	17
Moeling	25	0.56	14	0.44	11
Sekhonyana	30	0.57	17	0.43	13
Maputsoe	14	0.57	8	0.43	6
Moqalo	17	0.59	10	0.41	7
Total	**139**	**0.58**	**80**	**0.42**	**59**

3.6. Instrumentation

The main objective of research instrument is to obtain relevant information in the most reliable and valid manner. Thus, the accuracy and consistency of survey constitute a substantial aspect of research, better known as validity and reliability (Taherdoost, 2016). The instrument was developed with the assistance of literature and consultations with experts. The instrument consisted of close-ended questions.

3.6.1 Validity

Validity is the degree to which any measurement approach or instrument succeeds in describing or quantifying what it is designed to measure (Heale *at al*., 2015). To ensure that there was validity, the instrument was developed and submitted to three experts within the Department of Agricultural Economics and Extension in the Faculty of Agriculture of the National University of Lesotho (NUL) for review. Their views were incorporated during the final preparation of the research instrument.

3.6.2 Reliability

According to Heale *et al*. (2015) the reliability refers to the consistency of a research study or measuring test. If results or findings from research are replicated consistently, they are reliable.

Moreover, reliability is whether the researcher gets the same response by using an instrument to measure something more than once. That is, reliability is the degree to which an instrument produces stable and consistent findings (Bolarinwa, 2015). For this study, a test-retest method was done by conducting a pilot test using 20 farmers who did not form part of the study. The findings were processed and the correlation coefficient of 0.81 was recorded. These results were acceptable since they indicate a very strong correlation. Heale *et al*. (2015) emphasized that correlation coefficient of less than 0.3 signifies a weak correlation, 0.3 to 0.5 is moderate and greater than 0.5 is strong.

3.7. Data collection

Primary data was collected to in line with the research objectives. Primary data was collected directly from the farmers in the study area using the structured questionnaire. Before collecting data, the researcher had informal discussions on the instrument with farmers as to ensure their full participation.

3.8. Data analysis

The responses to the close ended questions were coded and subjected to different analytical tools. Descriptive statistics was used to describe socio economic characteristics of the farmers in the study area. Descriptive statistics involves the computation of means, standard deviation, frequency counts and percentages (Gaya *et al.,* 2017). In determining the level of adoption of improved maize production technologies, percentages were used to determine the rate of adoption.

Following Gaya *et al.* (2017) this study used the probit regression model to determine the factors influencing the adoption of improved maize technologies for the respondents to this study by gender. Probit is a binary choice model that can only assume two values of 1 or zero and tries to explain the probability that a farmer will choose an improved technology over a traditional technology based on some factors (Akudugu *et al*., 2012). This decision is a function of a set of socio-economic factors that likely affected the probability that male and female farmers adopted the technology or not. In this study, the dependent variable was the probability of adoption of improved maize technology by the farmers. Adoption in this study refers to a farm household, which used at least one technology (such as crop rotation, row planting, fertilizer, herbicide, pesticide, improved seed and irrigation).

The estimated probit model was specified as follows:

$$Y_i = \beta_0 + \beta_1 \sum_{i=1}^{10} Z_i + e_i$$

Where, Y_i is the dependent variable (Dummy: Adopt, 1; Non-adoption, 0)

The independent variables (Z_{is}) were:

- Farming experience (years)
- Household size (#)
- Hired labour (#)
- Access to credit (1= Access, 0= Non access)
- Confidence in extension skill (1= Yes, 0= No)
- Membership of a farmer group (1= Yes, 0= No)
- Farmers' training (1= Yes, 0= No)
- Self-sufficiency in maize production (1= Yes, 0= No)
- Walking distance to Agric office (Minutes)
- Access to ICT (1= Yes, 0= No)
- e_i is the error term
- β_0 and β_1 were parameters estimated

Table 3.3: Summary of data analysis

Objectives of the study	Variables	Source of data	Data analysis method
Describe the socio-economic characteristics of male and female farmers in the study area	Socio economic and institutional characteristics of male and female farmers	(Aguilar *et al*.,2015)	Descriptive Statistics ○ Percentages ○ Pie charts ○ T-test
Determine the level of adoption of maize production technologies	Level of adoption of maize production technologies	(Aneani *et al*.,2012)	○ Percentages ○ Chi square
Determine the factors influencing the adoption of improved maize technologies	Factors influencing the adoption of improved maize technologies	(Gaya *et al*.,2017)	Probit regression

3.9. Summary of the chapter

This chapter presented the methods that were used to analyse data. Data was obtained from a randomly selected sample of 80 male-headed households and 59 female-headed household producing maize crop in the study area. The study collected quantitative data, obtained from the use of structured questionnaires. Means and percentages were used to describe the socioeconomic and institutional characteristics of male and female farmers. The Chi square and percentages were also used in determining the level of adoption of improved maize production technologies. The study used Probit regression model to determine factors influencing adoption of improved maize technologies.

CHAPTER IV

4.0 FINDINGS AND DISCUSSION

4.1. Introduction

This chapter presents the findings of the study and discussion of the findings of the study. The chapter includes results and discussion of findings on the personal characteristics of both male-headed and female headed households in the study area, adoption rates for male and female farmers of improved maize production technologies and the determinants of improved maize production technologies in the study area.

4.2. Personal characteristics

4.2.1 Age

The age distribution of the male headed households who participated in the study is as follows; about 42.4 % of the respondents were male headed farming households and 38.8 % of female headed farming households who were above 51 years, according to Table 4.1. About 9.4 % of men and 3.6% of women were between 41 to 50 years, 4.3 % of male farmers were between 31 to 40 years, and 1.4 % of male farmers were less than 30 years. The results indicate that adults were more involved in the maize production across genders, in the study area. This might be because active youth in Lesotho migrate to South African farms looking for jobs with the better income. Kariyasa and Dewi (2011) emphasized that older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers.

Table 4.1: Distribution of respondents by age

Years	**Gender (%)**	
	Male	**Female**
Less than 30	1.4	0
31-40	4.3	0
41-50	9.4	3.6
Above 51	42.4	38.8
Total	**57.6**	**42.4**

4.2.4 Educational background

The education level of the respondents is shown in Table 4.2 below. The results in Table 4.2 show that 29.5 % of male farmers and 27.3 % of female farmers had completed primary education. About 15.8 % of men and 8.6 % of women had secondary education while 7.2 % of male farmers and 5 % of female farmers had no education. Only 5 % of males and 1.4 % of females had tertiary education. Majority of the farmers in the study area completed primary education. Gaya *et al.* (2017) noted that acquiring high level of education result in a positive adoption of technology and provide knowledge and skills needed to understand technology.

Table 4.2: Distribution of respondents by education

Years	**Gender (%)**	
	Male	**Female**
No education	7.2	5
Primary	29.5	27.3
Secondary	15.8	8.6
Tertiary	5	1.4
Total	**57.6**	**42.4**

4.2.5 Marital status

Of the 139 respondents about 47.5% of males were married. 2.9% of men were widowers while 29.5 % of women were widows. Only 2.9 % (males) and 10.8 % (females) were single. About 4.3 % of male and 2.2 % of females were divorced. Neway *et al*. (2022) found that married households are less likely to adopt agricultural technology than their counterparts as shown in Table 4.3. The reason is that unmarried farmers have few responsibilities and channel their financial resources to agricultural technology adoption contrary to their counterfactuals. Besides, marriage could result in a large family size, which would consequently put pressure on the financial resources, and limit the adoption capacity of the farm households.

Table 4.3: Distribution of respondents by marital status

Years	Gender (%)	
	Male	**Female**
Single	2.9	10.8
Married	47.5	0.0
Divorced	4.3	2.2
Widowed	2.9	29.5
Total	**57.6**	**42.4**

4.2.6 Description of the socio-economic characteristics by T Test

The independent T Test was conducted to compare the means of selected variables of male and female farmers in the study area and the results are shown on Table 4.4. There was significant difference in farming experience mean between male household heads (21.9 years) and female household heads (16.1 years) in the study area. This could be because in above 51years of age category; there were more male farmers than female farmers. Since age can serve as a proxy for farming experience, it implies that men have more years of farming experience than their female counterpart. The mean number of livestock owned by male farmers was 44 while that of the female head households was 16. There was significant difference at 1 %. This implies that an average male headed farming household had a higher asset holding status than an average female farmer. Men were more likely to use animal traction than female farmers. This result is consistent with the study of FAO (2011) which indicated that the average number of animals owned by men was higher than that of women. Women own fewer of the working animals needed in farming. There was a significant difference in the mean farm size of male (6.43) and female farmers (3.32) (p-value <0.01). This suggests that male farmers have larger farms than the female farmers and this might be attributed to the socio- cultural norms that restrict women's access to farmland in the study area. These results are confirmed in the study of Paramaiah (2021) who emphasized that cultural and traditional practices in Lesotho tend to discriminate women with respect to ownership of property hence majority of women in Lesotho have less access to land most especially for farming. In terms of land area allocated to maize production, there was a significant difference (p<0.01) between male farmers (3.19 acres) and female farmers (2.06 acres). The implication was that male headed households had better control and access over resources, particularly land, and therefore likely to try new innovations. These results concur with the study of Gebre *et al.* (2021) who emphasized that male headed households have larger area devoted to maize cultivation than female headed household. This is attributed to the large land holdings by male farmers. There was a significant difference in the average maize yield harvested in tons between the male farmers (1.84) and the female farmers (0.36), with a p value significant at 1 %. This could be attributed to the fact that female headed farming households had less land size compared to their male counterparts in the study area. The findings concur with the study of Doss (2018) who highlighted that women farmers have low production on their plots, and this was attributed to women having less access to and control of land resources compared their male counterparts. Furthermore, there was a significant difference in the mean numbers of hired labour by male headed household (1.28) and the female headed household (0.59) respectively, with p value significant at 1%. This might be caused by the fact that the demand for hired labour is very low for farmers with small land size, compared to farmers with large land size. The other reason could be that, female farmers are poor, and they could not afford to cater for large number of hired labourers in relation to household expenditures. Yahya (2014) emphasized that majority of female household heads are not financially capable to hire labourers in their farms since they consider them expensive. However, some of the female household heads who are financially stable hire labourers to increase their production.

Table 4.4: Socioeconomic characteristics by gender

Variables	**Gender**		**T-test**	**P>|Z|**
	Males	**Females**		
Farming experience	21.93(14)	16.07(10.6)	2.814*	0.006
Household size	6.11(2.96)	5.72(3.40)	0.710	0.479
Hired labour	1.28(1.87)	0.59 (1.41)	2.739*	0.007
Number of livestock	44.30(56.18)	16.05(23.14)	4.055*	0.000
Size of farming land (acre)	6.43(4.82)	3.32(1.69)	5.348*	0.000
Land allocated for maize (acres)	3.19(2.98)	2.06(1.07)	3.124*	0.002
Tons of maize	1.85(1.85)	0.36(0.36)	7.013*	0.000
Walking distance to seed dealers (min)	63.83(38.53)	71.84(46.39)	-1.081	0.282
Walking distance to market (min)	63.41(38.70)	74.45(48.08)	-1.451	0.150
Walking distance to Agric office (min)	51.95(36.85)	56.30(34.12)	-0.711	0.479

Note *significant at 1%, figures in parentheses () are standard deviations

4.2.7 Description of institutional characteristics by gender

Extension services provided by agricultural experts by design improve the farm productivity of rural households. The results indicated that 46 % of male farmers had access to extension services and 11.5 % of male farmers did not have access to extension services. Meanwhile, 22.3 % of female farmers had access to extension services and 20.1 % of female farmers did not have access to extension services as shown in Table 4.5. The p value of the chi square was 0.001 indicating that there was a significant relationship between gender and access to extension. This implies that men had better access to extension services than women in the study area. These results concur with the study of Ragasa *et al.* (2012) who confirmed that female headed farming households tend to lag male headed households in exploiting the benefits from extension services.

When the farmers interact with competent extension agents, they are likely to acquire the competence of the agents and may develop confidence to adopt technologies, believing competent agents will provide better services (Kassie *et al.*, 2013). About 47% of the male farmers had confidence in the skills and competencies of extension agents and 23 % of women had the confidence in the skills and competencies of the extension workers respectively. This result shows that a significant relationship exists between gender and the variable confidence in the skill of the extension staff, with the p value significant at 1 %. The disparity recorded here could be attributed to large number of women who failed to be part of information dissemination programmes in extension services. This is because some women spend a significant amount of their time on household activities including fetching fuel wood and water. Patil and Babus (2018) confirmed that apart from farming women perform various tasks related to home management such as collecting and carrying fuel over long distance, fetching water for cooking and drinking from distance place.

The study results show a significant relationship between gender and participation to field days with a p value significant at 1 % as shown in Table 4.5. About 36.7 % of male farmers were able to attend field days while 20.9 % of male farmers were not able to attend the field days. Only 12.9 % of female farmers participated in field days while 25.9 % of female farmers did not participate in field days. These results imply that the male farmers had better access to timely and relevant information about new technologies. There was a significant relationship between the variable participation in farm trials and gender with the p value significant at 1 %. About

23.7 % of male farmers participated in farm trials and 33.8 % of other male farmers did not participate in farm trials. About 8.6 % of female farmers participated in farm trials, while 33.8 % of female farmers did not participate in the farm trials. These results indicate that male farmers have more access to information about a technology compared to their female counterparts in the study area.

The results in Table 4.5 show a significant relationship between gender and farmers' training with the p value significant at 1%. About 38 % of the male farmers attended farmers' training and 17.3 % of the female farmers were able to attend farmer trainings The gender differences in farmer trainings, field days, farm trials and extension could be because except farming, women have multiple roles, including being mothers, housekeepers and care givers while majority of male farmers focus on farm work only. These findings are consistent with a study of Bamire *et al*. (2012) who found that, freedom of male mobility in participating in field days, farm trials and other technology demonstrations as compared to the females, give men more access to information on new technologies for their adoption.

The study results indicate a significant relationship between gender and the variable member of farmer group with a p value significant at 10 %. About 32.4 % of men were part of the social groups while 25.2 % of men were not part of the social groups. About 17.3 % of women were part of the social group and 25.2 % of women were not part of any social group. These results imply that there are more male farmers participating in social groups compared to women. These results could be since some resource poor female farmers could not meet the financial requirements of financial subscriptions for membership to some associations in the study area. The other reason for low participation of female farmers in social groups could be due to challenge of groups, cooperatives and associations in Lesotho due to constant disputes. These results are like those of the World Bank (2010) which confirmed that membership or participation in farmer associations may be limited to a particular civil status or criteria that may exclude women and other resource-poor farmers.

Male headed households had more access to ICT devices such as mobile phones, radio and TV compared to their female counterparts. There was a significant relationship between gender and the variable ICT with the p value significant at 1%. According to these results, access to ICT is dependent on gender. Only 56.1% of male farmers had access to ICT while 1.4 % of male farmers did not have access to ICT. About 28.8 % of women had access to ICT and 13.7 % of women did not have access to ICT. This could be since after farm work; men are able to listen to the radio and watch television while women would be busy with the household chores.

Table 4.5: Institutional characteristics

Variables		**Males (%)**	**Females (%)**	**$\chi 2$**	**P >| Z|**
Access to off farm income	Yes	29.5	27.3	2.396	0.122
	No	28.1	15.1		
Access to credit	Yes	9.4	6.5	0.25	0.874
	No	48.2	36.0		
Participation in field days	Yes	36.7	12.9	15.01	0.000
	No	20.9	29.5		
Access to extension services	Yes	46	22.3	11.83	0.001
	No	11.5	20.1		
Confidence in the skill of extension	Yes	46.8	23	11.75	0.001
	No	10.8	19.4		
Member of a farmer group	Yes	32.4	12.2	3.24	0.072
	No	25.2	30.2		
Participation in farm trial	Yes	23.7	8.6	6.78	0.009
	No	33.8	33.8		
Participation in farmer trainings	Yes	38.1	17.3	8.98	0.003
	No	19.4	25.2		
Access to ICT	Yes	56.1	28.8	23.36	0.000
	No	1.4	13.7		

4.3.1. Adoption of improved maize production technologies

Adoption in this study refers to a household head farmer who practiced at least one technology (such as crop rotation, row planting, fertilizer, herbicide, pesticide, improved seed and irrigation). Table 4.6 shows the distribution of adopters and non-adopters. The total number of adopters was 98 farmers while 41 farmers were non adopters. Out of 139 respondents (80 men and 59 women), 17.5% of male headed households (14) and 45.8% of female headed households (27) did not adopt to maize production technologies while 82.5% of men (66) and 54.2% of women (32) did adopt maize production technologies. The value of the chi square was 28.522, with p value significant at one percent. This indicates a significant relationship between the variable adoption and gender in favour of men. More male (82.5%) farmers had adopted maize production technologies compared to their female counterparts (54.2%). This could be since women have less access to finance and other resources compared to men. These findings are like the study of Hailu *et al*. (2014) who confirmed that female-headed households were less likely to adopt modern maize technologies as compared to male-headed households. This is because male-headed farmers have better access to resources like land, labour, and other inputs than female-headed farmers.

Table 4.6: Distribution of adopters and non adopters of improved maize production technologies

Variable		**Gender**		χ^2	**df**	**P < |Z |**
	Male	**Female**	**Total**	28.522	1	0.000
Adopters	66 (82.5%)	32 (54.2%)	98 (70.5%)			
Non adopters	14 (17.5%)	27 (45.8%)	41 (29.5%)			
Total	**80 (100%)**	**59 (100%)**	**139 (100%)**			

Adoption level for each technology was further determined to show the distribution of adoption rate on each maize production technology (CA, crop rotation, row planting, improved seeds, inorganic fertilizer, pesticides, herbicides and irrigation). The following adoption percentages on each technology are based on 98 (66 males and 32 females) farmers who are maize production technologies adopters in Table 4.6.

4.3.2 Adoption by gender: CA

According to Table 4.7, out of 98 (66 males and 32 females) maize production technology adopters, only 21.2% of male farmers practiced conservation agriculture while 78.8% of male farmers did not practice conservation agriculture. About 21.9% of female farmers were practising CA and 78.1% of female farmers were not practising CA. Majority of the farmers who were engaged in CA were using manual seeding to sow the maize seed. According to Table 4.7, the results of the Chi Square analysis show that there was no significant relationship between gender and adoption of conservation agriculture by farmers (maize production technology adopters) in the study area implying that adoption of conservation agriculture was not dependent on gender.

Table 4.7: Distribution of adopters and non adopters: CA

Variable	Gender		χ^2	df	P > |Z |
	Male (%)	**Female (%)**	0.006	1	0.940
Adopters	21.2	21.9			
Non adopters	78.8	78.1			
Total	**100**	**100**			

4.3.3. Adoption by gender: Crop rotation

According to Table 4.8, out of 66 male and 32 female maize production technology adopters, about 93.9% of men were practising crop rotation while the other 6.1% of men were not rotating crops on their farms. About 75% of female farmers were rotating crops on their farms and 25% of females were not rotating crops. The p value of the chi square test was 0.007 indicating that the relationship between adoption of crop rotation and gender and was statistically significant in favour of male farmers. These imply that crop rotation was dependent on gender. More male farmers adopted crop rotation when compared to the female farmers and it could be because men have better access to extension services than women in the study area. The results are consistent with the study of Reddy *et al*. (2017) who confirmed that the number of female farmers practicing crop rotation is less than the number of their male counterparts.

Table 4.8: Distribution of adopters and non adopters of crop rotation

Variable	Gender		χ^2	df	P > |Z |
	Male (%)	**Female (%)**	7.194	1	0.007
Adopters	93.9	75			
Non adopters	6.1	25			
Total	**100**	**100**			

4.3.4. Adoption by gender: Row planting

Majority of the farmers in the study area used ox drawn planters to make rows when sowing seed while very few used tractors. In the study area 98.5% of male farmers who were categorized as adopters planted maize seed in rows while 1.5% of male farmers did not plant seed in rows and 87.5% of female farmers planted maize in row while 12.5% of female farmers did not practice the row farming. As shown on Table 4.9, the chi square value was 5.371 with a p value at 0.020, implying that there was a significant relationship between gender and adoption of row planting. Adoption of row farming was dependent on gender in favour of male farmers among maize production technology adopters. Male farmers were more involved in row farming compared to their female counterparts, and this might be caused by the fact that women owned few animals that can be used for farming purposes.

Table 4.9: Distribution of adopters and non adopters of row planting

Variable	**Gender**		χ^2	**df**	**P > |Z |**
	Male (%)	**Female (%)**	5.371	1	0.020
Adopters	98.5	87.5			
Non adopters	1.5	12.5			
Total	**100**	**100**			

4.3.5. Adoption by gender: Improved seeds

Some of the improved maize seed varieties that some of the farmers in the study area used include DKC 7372, Panaar, SNK 2778, SAHARA, Okavango, and PHB 33H56. Farmers who could not afford to buy improved maize seed varieties were sowing seed varieties from the previous harvest. All these improved seed varieties were among the varieties that were recommended and subsidized by the Ministry of Agriculture through the Department of Crop Services. About 93.9% of male headed households planted improved maize varieties while 6.1% of male farmers did not plant improved maize varieties. Only 37.5% of female farmers planted improved maize seed varieties and the other 62.5% of female farmers did not plant improved maize varieties as shown on Table 4.10. According to the Chi square value of 37.123 with a p value at 0.000, there was a significant relationship between gender and adoption of improved maize varieties, with men dominating in using improved maize varieties compared to female farmers. This might possibly be due to poor participation of women in farmer trainings, field days and farm trials compared to their male counterparts. These results are consistent with the study of Agarwal (2015) who noted that women are less likely than men to use yield-enhancing inputs such as fertilizer and improved seeds/cultivars.

Table 4.10: Distribution of adopters and non adopters of improved seeds

Variable	Gender		χ^2	df	P > |Z |
	Male (%)	**Female (%)**	37.123	1	0.000
Adopters	93.9	37.5			
Non adopters	6.1	62.5			
Total	**100**	**100**			

4.3.6. Adoption by gender: Herbicides

Herbicides were applied in the maize fields as a weed control measure. The study results on Table 4.11 show that 13.6% of male farmers were using herbicides while the other 86.4% of male farmers did not use herbicides. None of the female farmers applied herbicides. The chi square value was 4.805 with a p value at 0.028. These results show a significant relationship between gender and the herbicides adoption. Adoption level was higher among men. This could be because the female farmers were financially poor, and they could not afford to buy herbicides. The other reason for the gender gap in herbicides application could be that women had less access to information on herbicides since majority of them could not have access to extension services compared to men.

Table 4.11: Distribution of adopters and non adopters of herbicides

Variable	Gender		χ^2	df	P > |Z |
	Male (%)	**Female (%)**	4.805	1	0.000
Adopters	13.6	0.0			
Non adopters	86.4	100			
Total	**100**	**100**			

4.3.7. Adoption by gender: Fertilizer application

The fertilizers that were applied in the study area were Inorganic fertilizer and kraal manure. About 87.9% of male farmers were applying the organic fertilizer in their maize farms while 12.1% of male adopters were not applying the fertilizers in their maize farms. About 71.9% of female adopters were applying organic fertilizer in their maize fields and 28.1% of female farmers were not applying organic fertilizer in their maize fields. The chi square value was 3.850, with the p value significant at 5%, showing the significant relationship between adoption of fertilizer and gender. The results of this study as shown in Table 4.12 indicate that fertilizer application is dependent on gender. Male farmers had the higher adoption level than female farmers. The gender difference in the use of the fertilizers could be due to women owning low animal population which limits their access to kraal manure. Women in the study area were poor compared to men and they could not afford to buy inorganic fertilizers. These results are consistent with the study of Agarwal (2013) who noted that women are less likely than men to use yield-enhancing inputs such as fertilizer and improved seeds.

Table 4.12: Distribution of adopters and non adopters of fertilizer application

Variable	**Gender**		χ^2	**df**	**P > |Z |**
	Male (%)	**Female (%)**	3.850	1	0.050
Adopters	87.9	71.9			
Non adopters	12.1	28.1			
Total	**100**	**100**			

4.3.8. Adoption by gender: Pesticides application

Pesticides were among the maize production technologies that were used by the household heads in the study area. As shown on table 4.13, about 65.2% of male headed households were applying pesticides in their fields and 34.8% of male headed households were not applying the pesticides in their maize farms. Only 3.1% of female headed households were using pesticides to control insects and 96.9% of female headed households were not applying pesticides to control insects. The Chi square value of 33.514 with a significant p value (0.000) at 1 percent level of significance indicates that there is a significant relationship between gender and adoption of pesticides among maize production adopters in the study area. Pesticides application is dependent on gender. Male headed households had a higher adoption rate. This could be because many women in the study area were worse off hence they could not buy pesticides. The lack of knowledge to determine the amount and the skills to apply pesticides could be a problem for female farmers. These findings are consistent with the study of Tsige *et al.* (2020) who emphasized that it has been identified that women have restricted access to information on the risk and profitability of agricultural technologies such as pesticides and herbicides.

Table 4.13: Distribution of adopters and non adopters of pesticides application

Variable	**Gender**		χ^2	**df**	**P > |Z |**
	Male (%)	**Female (%)**	33.514	1	0.000
Adopters	65.2	3.1			
Non adopters	34.8	96.9			
Total	**100**	**100**			

4.3.9. Adoption by gender: Irrigation

Farmer's application of irrigation in the study area was very low as shown on Table 4.14. Out of 66 male and 32 female maize production technology adopters, only 9.1% of male farmers irrigated their maize plots and 90.9% of male did farmers did not irrigate their maize plots, while none of female farmers irrigated their maize plots. All the farmers who irrigated on their farms were using the sprinkler as the method of irrigation. The value of the chi square was 3.099, with the p value at 0.078, not significant at 5% level of significance. Since the p value is greater than 0.05 showing no significant relationship between gender and adoption rate in irrigation. This implies that adoption of irrigation was not dependent on gender.

Table 4.14: Distribution of adopters and non adopters of irrigation

Variable	**Gender**		χ^2	**df**	**P > |Z |**
	Male (%)	**Female (%)**	3.099	1	0.078
Adopters	9.1	0			
Non adopters	90.9	100			
Total	**100**	**100**			

4.4.0 Factors influencing adoption of improved maize production technologies

The probit regression model was used in determining the relationship between a set of 10 control variables and the response variable (adoption of maize production technologies). The control variables included farming experience, household size, family labour, access to credit, confidence in extension skill, member of a farmer group, farmer trainings, Self-sufficiency in maize production, walking distance to Agric office (minutes) and access to ICT which are possible determinants of adoption of maize production technologies. The probit model was used to determine the factors that influence adoption/access to maize production technology without considering the gender analysis, and the model was also used to describe the same factors by gender. The probit model that described the factors that influence the improved maize production technologies without considering gender was summarized in Table 4.15. The control variables in Table 4.15 were described by their coefficients, to determine their relationship with the response variable. The coefficients of the marginal effect were used in Table 4.16 to describe the impact that the changes in explanatory variables have on the probability of adopting new technologies for each gender.

4.4.1 Determinants of adoption of improved maize production technologies for all farmers

To evaluate the determinants of adoption of improved maize production technologies the study used a probit regression model and Table 4.15 presents the results. The empirical estimations have been done by the maximum likelihood method with the model significant at 1%. The results of Chi square test indicated that the likelihood ratio statistics was also significant (p value = 0.000), indicating that the model had a strong explanatory power. The empirical results of the probit econometric model showed that farming experience, confidence in extension skill, member of a farmer group, walking distance to Agric office (minutes), farmer's training, access to ICT significantly influenced adoption of improved maize production technologies for all farmers in the entire sample. The coefficients of farming experience, confidence in extension skill, member of a farmer group, farmer training, access to ICT had positive signs. This implies that for every unit increase in any of these variables, the rate of adoption increases by the magnitude of their coefficients; 0.51 units for farming experience, confidence in extension skill (0.52), member of a group (0.81), farmer trainings (0.51) and ICT (0.70) units. Similarly, the coefficient of walking distance to Agric office (minutes) has negative sign. This implies that for every unit increase in walking distance to Agric office (minutes), there is a reduction in the rate of adoption of improved maize production technology by the magnitude of 0.4. It means that farmers who are very close to extension agents have better access to agricultural information.

According to the results presented in Table 4.15, there is a positive relationship between farm experience and adoption of improved maize technology which could be because farming experience improves farmers' skills in production, which implies that more experienced farmers may have a low level of uncertainty about improved agricultural innovations performance and be able to evaluate the advantages of new agricultural technology (Adedoyin et al., 2016). Annor (2013) argued that the number of years in farming affect adoption behaviour as it is assumed that adoption of one technology predisposes the farmer to adopt other technology. The results summarized in Table 4.15 show the positive association between adoption of improved maize technology and the variable farmer's confidence in the skill of extension worker and it could be because extension workers' skills and competencies as a basic characteristic of a person influence the farmers way of thinking, acting, and making generalization about a technology (Bahua, 2016). These findings are consistent with a study by Beyene *et al*. (2015), who confirmed that confidence in the skill of extension workers would increase the rate of adoption. Improving the skills and competencies of the extension workers through, for example, refresher courses, training on new technologies and increasing their acceptance by the farmers will speed up the adoption process. The results of the study show a positive relationship between the variable member of a farmer group and adoption of improved maize technology, which implies that the more farmers are involved in farmer organizations' meetings and activities, the more they will access new information about improved technologies and the more they will easily develop positive attitude towards the adoption of maize of production technology. These results are consistent with the study of Onyeneke (2017) who confirmed that farmers who are actively participating in social organizations had increased likelihood of adopting technology.

There was a positive relationship between the variable access to farmer trainings and adoption of improved maize technology, which implies that training farmers can help them in the assimilation of information and therefore they adopt improved technology much more comfortably than the farmers who have no access to training. Mgendi (2022) emphasized that training can give farmers the necessary skills and knowledge and change their attitudes and behaviours towards accepting improved technologies. There was a negative relationship between the variable walking distance in minutes to agricultural office and adoption of improved maize technology. The agricultural office serves as proxy for access to agricultural extension agents. Access to extension agents will increase farmers' awareness and information on the importance of technology adoption (Akpan *et al.*, 2012). These findings were like those for the study by Kassie *et al*. (2015) who found that shorter distances to extension services may help farmers to have better access to extension service and that is information positively affecting the adoption. The longer distances negatively affect the adoption. There was a positive relationship between the variable ICT and adoption of improved maize technology. The implication is that farmers who owned radios, televisions and smart phones at their homes probably tend to use the improved maize technologies than those households who have no radio at their home. These findings are consistent with the study by Gecho (2011) who indicated that access to ICT is systematically associated with adoption of improved maize technologies

Table 4.15: Factors influencing adoption of maize technologies for both genders

Variable	**Coefficient**	**Standard error**	**Z**	**P > | z |**
Farming experience	0.5102609**	0.2139426	2.39	0.017
Household size	0.0870371	0.1489744	0.58	0.559
Hired labour	0.3855034	0.1489744	1.28	0.199
Access to credit	-0.5434817	0.4022824	-1.35	0.177
Confidence in extension skill	0.519073***	0.2872659	1.81	0.071
Member of a farmer group	0.7697386**	0.3416635	2.25	0.024
Farmer trainings	0.5122202***	0.2909751	1.76	0.078
Self-sufficiency in maize production	0.3471553	0.6832573	0.51	0.611
Walking distance to Agric office (min)	-0.4082333*	0.1233535	-3.31	0.001
Access to ICT	0.7050444	0.3488469	2.02	0.043
Constant	-1.15866	0.65609	-1.77	0.077

Number of observations = 139

LR chi2(10) = 50.68

Log likelihood = -56.19

Pro>chi2 = 0.0000

Pseudo R2 = 0.3108

* Significant at 1%, ** Significant at 5%, *** Significant at 10%

4.4.2 Determinants of adoption of improved maize production technologies by gender analysis

To evaluate the determinants of adoption of improved maize technology by gender. The empirical results of the probit econometric model in Table 4.16 showed that adoption of improved maize technology by male farmers was positively influenced by farming experience, farmer's training, while household size and the variable distance to Agric office negatively influenced adoption of improved maize production technologies. Adoption of improved maize technology by female farmers was positively influenced by farming experience, household size, confidence in extension worker skill, farmer's trainings, access to ICT and negatively influenced by the variable distance to agricultural office. The empirical estimations have been done by the maximum likelihood method with the model being highly significant at 1%. The results of Chi square test indicated that likelihood ratio statistics was also significant with different p values. Thus, (P value = 0.005 on adoption by male farmers) and (p value = 0.000 on adoption by female farmers), indicating that the model had a strong explanatory power.

The probit model results from Table 4.16 indicated that farming experience of household head was positively associated with adoption of improved maize technology for both male and female farmers at 10% significant level. The coefficient of the marginal effect for both male and female farmers was 0.1. The implication was that, for an extra year of farm experience acquired in both genders, the probability of the adoption of improved maize production technology increased by 0.1. This means that male and female farmers who had more years of farm experience were more likely to adopt improved maize technology than those farmers who had less years of farm experience. These results confirmed the study done by Challa (2014), who indicated that farmers with higher experience appear to have often full information and better knowledge and were able to evaluate the advantage of the technology. Hence it is hypothesized to affect adoption positively.

The variable household size negatively influenced the adoption of improved maize production technology by male farmers at 5% significant level while positively associated with the adoption of technology by female farmers at 5% significant level. The coefficients of the marginal effect for male and female farmers were -0.1 and 0.1 respectively. This means that in the male headed households, the probability of maize production technology adoption reduced by 0.1 for every member increase in the farming household head's family. The implication is that, as the family size of the male headed household increases, the probability of adopting maize production technologies decreases. These results are consistent to the study of Akpan *et al*. (2012) who emphasized that an increase in the household size would increase the family expenditure and probably reduce farm expenditures. With respect to the female headed households the results show that, for one member increase in household size, the likelihood of adoption increased by 0.1. These findings concur with those of Tanellari *et al*. (2014) who confirmed that female-headed households are more likely to adopt if there are more people living in the household. This could be an indication of the availability of additional labour, as improved technologies are generally more labour intensive.

Table 4.16: Adoption of improved maize technology by gender

Variables	Males			Females		
	Coefficient (Std error)	**p>| z |**	**Marginal effect**	**Coefficient (Std error)**	**p>| z |**	**Marginal effect**
Farming experience	0.60(0.34) ***	0.075	0.11	0.61(0.37)***	0.098	0.13
Household size	-0.65(0.32) **	0.041	-0.12	0.45(0.22) **	0.037	0.10
Hired labour	0.77(0.48)	0.106	0.15	0.67(0.51)	0.189	0.15
Access to credit	0.02(0.53)	0.973	0.00	-0.33(0.63)	0.595	-0.07
Confidence in extension skill	0.23(0.54)	0.667	0.04	0.86(0.46)***	0.059	0.19
Member of a farmer group	0.91(0.49) ***	0.065	0.16	0.67(0.52)	0.199	0.15
Farmer trainings	0.89(0.49) ***	0.067	0.18	0.86(0.50)***	0.086	0.20
Self -sufficiency in maize production	0.79(0.70)	0.257	0.12	-0.23(0.74)	0.759	-0.05
Walking distance to Agric office (min)	-0.47(0.25) ***	0.057	-0.08	-0.70(0.25) *	0.005	-0.15
Access to ICT	-0.03(0.77)	0.964	-.01	0.95(0.56)***	0.089	0.21
Constant	0.25(1.15)	0.830		-2.54(1.21)	0.036	
Number of observations	80			59		
LR chi2(10)	25.32			36.63		
Log likelihood	-25.945			-22.570		
Pro>chi2	0.005			0.000		
Pseudo R2	0.3280			0.448		

***; **; * means statistically significant at 10%, 5% and 1%, figures in () are standard errors

Regarding the perceptions of female farmers on the competence and skills of extension workers, the results revealed that there was a positive relationship between the variable confidence in the skills of the extension agent and the likelihood of the adoption of improved maize production technology. The coefficient of the marginal effect was 0.2 indicating that a unit increase in female farmer's confidence in the skills of extension worker would increase the probability of adoption of improved maize technology by 0.2. According to these results, female headed households that had confidence in the skills of extension agents are more likely to adopt improved maize production technologies. The findings are consistent with Beyene *et al*. (2015), who confirmed that confidence in the skills of extension workers would increase the rate of adoption. Improving the quality of the extension workers through, for example, upgrading their skills and increasing their acceptance by the farmers will speed up the adoption process.

According to the results shown in Table 4.16, the variable member of the farmer's group was found to be statistically non-significant to influence adoption of technology by female farmers. This may probably be due to the fact that women who are part of farmer groups might not be participating actively due to their multiple roles that include being mothers, housekeepers and care givers. The variable member of the farmer's group positively influenced the improved maize production technology adoption by male farmers and was statistically significant at 5%. The coefficient of the marginal effect was 0.2, implying that; a unit increase in the variable would increase the probability of adoption of improved maize technology by 0.2. Male farmers who joined associations and other social groups were more likely to adopt improved maize production technologies. These findings were consistent with those of Sisay *et al*. (2015) who observed that membership in a group has a positive influence on improved maize production technology. Membership of farmer-based organizations is an essential source of information. Farmers get a lot of information regarding production and marketing through a farmer-to-farmer network (Danso-Abbeam *et al.*, 2017). The variable walking distance (min) to agricultural office was inversely related with the adoption of improved maize technology for both male and female farmers at different significance level, 10% and 1% respectfully.

The coefficients of the marginal effect for male and female farmers were -0.1 and -0.2 respectfully. Each unit increase in the distance to the agricultural office appeared to decrease the probability of adoption of improved maize technology by 0.1 for male farmers and 0.2 for female farmers. This means as a distance to agricultural extension office increases, the likelihood of adoption of improved maize technology would decrease. The assumption was that the further away a farmer is from the agricultural office, the less likely it is that the household will receive services from extension agents. These results concur with findings of the study by Raut *et al.* (2011), who emphasized that the distance to an agricultural office has been known to influence adoption of agricultural technology. Therefore, the coefficient on the distance of the household to the extension office is expected to be negative. Accessibility to trainings for both genders positively influenced adoption of improved maize production technologies. The variable access to training was significant at 10% level for both genders. The positive marginal effect of 0.2 for both genders indicated that an additional training to the farmers would increase the probability of adoption of improved maize production technology by 0.2. The implication was that, providing much training on both genders will increase the probability of using improved technologies. This finding corresponded with Henry *et al.* (2012), Giné and Yang (2008) who also found that access to farmer training increases participation in improved technology.

According to the results summarized in Table 4.16, access to ICT devices such as mobile phones, radio or TV had a positive and significant effect in relation to adoption of maize production technologies by female farmers. This can be caused by the fact that even if the women fail to be part of information dissemination programmes in extension services due to household chores and other family commitments, they still can get information via ICT. The coefficient of the marginal effect was 0.2, implying that the unit increase in access to information from ICT devices would increase the probability of adopting maize production technology by 0.2. Therefore, it means that accessibility to ICT devices increases the likelihood of accessing information on improved agricultural technologies. For instance, there are several agricultural production programmes on local television and radios that focus on dissemination of different agricultural technologies. Thus, female household heads with access to information are more likely to be influenced to adopt improved agricultural technologies. These results are strongly supported by Mottaleb *et al.* (2018), who found that farmers who are better informed about improved agricultural technologies have better chances of adopting agricultural technologies than farmers who are relatively less informed.

CHAPTER V

5.0 SUMMARY, CONCLUSION, AREA OF FURTHER STUDY AND RECOMMENDATIONS

5.1. Introduction

This chapter provides the summary, conclusion, implications of the study results and areas for further study. The conclusions and recommendations of the study are based on the study findings from the previous chapter. This study focused on the factors influencing adoption of improved maize production technologies and the determinants of adoption of improved maize production technologies by gender. The chapter uses the findings of the study for each of the objectives to draw up conclusions of the study. The chapter presents the policy implications of the study to assist farmers and policy makers in appreciating determinants of adoption of improved maize production technologies with a focus on gender parity that will improve livelihoods of both men and women maize farmers.

5.2. Summary of the study

The main objective of the study was to investigate the gender differential in agricultural productivity with focus on technology adoption of maize farm households in Quthing. There are three specific objectives of the study. These are to: describe the socio-economic and institutional characteristics of male and female farmers. Secondly, determine the adoption level of male and female farmers on improved maize production technology. Lastly, determine the factors influencing the adoption of improved technologies in maize production. The study obtained data from a randomly selected sample of 80 male-headed households and 59 female-headed household producing maize crop in the study area. The study collected quantitative data, obtained from the use of structured questionnaires. Means and percentages were used to describe the socioeconomic and institutional characteristics of male and female farmers. The Chi square and percentages were also used in determining the level of adoption of improved maize production technologies. The study used Probit regression model to determine factors influencing adoption of improved maize technologies.

The results of the study showed evidence of gender variation in the socioeconomic and institutional characteristics of both male and female farmers, adoption level of male and female farmer on improved maize technologies and the determinants of adoption of improved maize production technologies. The results of the independent t-test were in favour of men in relation to the mean differences of socioeconomic characteristics that were significant between male and female farmers, which included farming experience, hired labour, number of livestock, size of the farming land (acres), land area allocated to maize production (acres), and maize yield in tons. Male farmers also had an advantage compared to their female counterparts with respect to participation in institutional factors such as field days, access to extension services, member of a farmer group, farm trials, farmer trainings, and access to ICT. The Chi-square test that had a p value that was significant at all levels of significance confirms the foregoing. In determining the adoption level of male and female farmers on improved maize production technology, the results of the Chi-square test showed a significant relationship between gender and adoption of different maize production technologies in favour of men. The maize production technologies under study included CA, crop rotation, row planting, improved seeds, herbicides, pesticides, fertilizers and irrigation.

More male (82.5%) farmers had adopted maize production technologies compared to their female counterparts (54.2%). This was confirmed by a chi square test with the p value significant at one percent. The factors that significantly influenced adoption of improved maize technologies in the study area were farming experience, confidence in extension skill, farmer group, and farmer trainings and walking distance to Agricultural office. While farming experience, household size, farmer trainings and walking distance to Agricultural office were common factors that drive the adoption of improved maize technology by both male and female farmers; the variable member of a farmer group was specific to male farmers, while the variable confidence in extension skill and access to ICT were specific to female farmers.

5.3. Conclusions of the study

Maize farms owned by female household heads had lower yields compared to maize farms owned by their male counterparts. This implies that majority of female household heads could not get income from selling surplus maize yield, meaning they were financially poor compared to male farmers. Male farmers had larger farms than the female due to socio-cultural norms that attribute the control and access of land to men. The implication of this is that male headed households have better control and access to resources, particularly land, and therefore more likely to try new innovations. As a result, male headed households had larger area devoted to maize cultivation than female headed household which was attributed to the large land holdings by male farmers. Men were dominating women in relation to livestock ownership. Due to this, men were more likely to use animal traction than female farmers. The male headed household had more hired labour compared to female headed household. This is because female farmers were poor, and they could not afford to cater for large number of hired labourers in relation to household expenditures. More male-headed households were adopters of technology than female-headed households. There were evident differences across gender in terms of farming experience, household size, member of a farmer group, farmer trainings, access to ICT, and membership in farm cooperatives, land size, and livestock assets.

The study assessed male headed households and female headed households' level of adoption to different maize production technologies such as CA, row planting, crop rotation, improved maize seeds, pesticides, herbicides, fertilizer application and irrigation. It was found that more men adopted row planting compared to women. This is because male farmers had more access to hired labour and were more likely to use animal traction compared their female counterparts. Adoption rate of crop rotation was higher on men than female farmers. This is likely because men had better access to extension services than women in the study area. Women lag behind men with respect to adoption of improved seeds and organic fertilizer. This is because of poor income and access to credit, poor participation of women in farmer trainings, field days and farm trials compared to their male counterparts. Men had higher adoption rate on herbicides and pesticides compared their female counterparts. This is likely because majority of women in the study area were financially worse off compared to their male counterparts hence they could not afford to buy pesticides.

The following factors influenced the adoption of improved maize production technology by all farmers in the study area. The higher the level of farming experience, the higher the likelihood of adoption of improved technology. This is because farming experience improves farmers' skills in production, which implies that more experienced farmers have a low level of uncertainty about improved agricultural innovations performance and can evaluate the advantages of new agricultural technology. An increase in the level of confidence in the skill of extension officer increases the likelihood of adoption of maize production technologies. The extension workers' skills and competencies influence the farmers' way of thinking, acting, and influence the farmers' perception and overall acceptance of a technology. The study results indicated a positive relationship between the variable member of the farmer group and adoption of improved maize technology. This is because most of the new agricultural technologies and new methods of farming are disseminated through the farmer-based organizations. There was a positive association between farmers' training and adoption of improved maize production technology. This is because training farmers help them in the assimilation of information and therefore, they adopt improved technology much more comfortably than the farmers who have no access to training. There was a negative relationship between the variable walking distance to agricultural office and the likelihood of adoption of improved maize technology. The agricultural office serves as proxy for access to agricultural extension agents. Access to extension agents increases farmers' awareness and information on the importance of technology adoption.

The adoption of improved maize production technology by gender was influenced by a number of factors. There was a positive relationship between farming experience and adoption of improved maize technology by both male and female farmers. This is because farming experience improves farmers' skills in production, which implies that more experienced farmers may have a low level of uncertainty about improved agricultural innovations performance and they are able to evaluate the advantages of new agricultural technology. There was a positive association between the household size and adoption of improved maize technologies by female farmers. This result implies that availability of labour increases the likelihood of female headed households' adoption of improved technologies since some improved maize production technologies are generally more labour intensive. The study results revealed a negative relationship between the household size and adoption of improved maize technologies by male farmers. This might be due to the increase household expenditure associated with increase in the household size which probably reduces farm expenditures.

The study results indicate a positive relationship between the variable farmer training and the likelihood of adoption of improved maize technology by both male and female farmers. This is because training farmers helps them in the assimilation of information and therefore, they adopt improved technology with ease compared to the farmers who have no access to training. There was a negative relationship between the variable walking distance to agricultural office and the likelihood of adoption of improved maize technology by both male and female farmers. The agricultural office serves as proxy for access to agricultural extension agents. Access to extension agents increases farmers' awareness and information on the importance of technology adoption. The high level of participation in the farmer group increases the likelihood of adoption of improved maize technology by male farmers. Membership of farmer-based organizations increases likelihood of farmers' access to essential information. Farmers in the study area accessed a lot of information on production and marketing through farmer-to-farmer networks. There was a positive relationship between the variable confidence in extension skill and the likelihood of adoption of improved maize technologies by female farmers. Therefore, improving the competencies and skills of the extension officers through, for example, refresher courses will increase confidence of female farmers in their advice hence speed up the technology adoption process. There was a positive association between access to ICT information and adoption of improved maize technology by female farmers. The implication is that even if women failed to be part of information dissemination programmes in extension services due to household chores and other family commitments, they still could access extension information and messages via ICT.

5.4. Recommendations

- The study recommends that more attention be given to women farmers especially trying to reduce cultural barriers that make them have less access to land.
- Government must promote agricultural financial instruments and programmes that favour women which will increase access to finance for rural female farmers. Women in most cases lack financial resources to adopt improved technologies.
- Women should make use of their micro-finance initiatives to finance their farming operations.
- The Input Subsidy programme by the Ministry of Agriculture and Food Security should provide timely, affordable and quality inputs which will increase agricultural productivity and therefore farm household incomes. Distribution of inputs under these programmes should be on a gender parity basis.
- The study encourages the formation of farmer-based organizations (FBOs) in the study area. It further recommends that agricultural development programmes should target FBOs as well as support them with technical training to enhance technology uptake. Extension officers should encourage maize growers to join FBOs by making them aware

of the benefits of joining such organizations. In places where such organizations do not exist, the extension officers should facilitate their formation. Extension officers must encourage women to form and join these FBOs, through clearly articulating their benefits.

- Farmers must have access to information through the radio, television and the mobile phone platforms. Public and private extension must facilitate access to information for farmers through these platforms since most farmers own ICT devices especially radio and mobile phones. Women farmers can benefit from ICT to access information since sometimes they fail to attend public gatherings due to domestic chores, family and nurturing responsibilities. The study recommends broadcast of more agricultural programmes on national and local radios and television stations. All agricultural programmes should be aired at good and appropriate time that will be convenient for the farmers both male and female. Famers should use social media platforms as forums to exchange ideas; mobilize for a cause; seek advice and offer one another guidance.
- Ministry of Agriculture and Food Security should intervene in reducing long distances travelled by farmers to agricultural extension offices. Considering that most NGOs that provide private extension services do not have staff at the grassroots level and therefore rely on the government extension workers. The study recommends that these organizations must increase their investments in human resources at the grass root levels, that is, employ more field extension staff to reduce long distances travelled by farmers to agricultural extension offices. Increasing the number of field extension staff will reduce the staff-to-farmer ratio to manageable levels which will enable extension services to be more accessible for both male and female rural farmers.
- The study recommends training of farmers on improved maize production technologies. Extension officers must disseminate relevant information about the technologies to the farmers. The Lead Farmer concept should be utilized since this help to improve adoption of improved technology because farmers are often more willing to learn from their colleagues than from extension staff. Exchange visits and field days should also be facilitated. Agricultural Extension officers should also facilitate farmer training workshops and field visits for the farmers. There should be training equipment and

infrastructure such as community training halls that will provide a good learning environment under all climatic conditions.

- The study recommends capacity building of extension agents on modern maize production technologies to increase their work competency. Some study tours should be organized for extension agents locally, in Lesotho and in RSA to learn about different maize production technologies that improves agricultural production and productivity. The Ministry of Agriculture should join hands with its partners, especially Lesotho Agricultural College and National University of Lesotho to devise some strategies aimed at improving the capacity of the extension officers to improve their work competency.

5.5. Area for further research

This study focused on gender differentials and the determinants of factors influencing adoption of improved maize production technologies in the study area. Future studies need to investigate on the quantified differences in productivity amongst the various improved maize production technologies for both male and female farmers. It may also be prudent to conduct a Principal Component Analysis on both male and female production and productivity data to determine the contribution of each of the improved technologies to maize production and productivity.

REFERENCES

Abdoulaye, T., Abass, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. and Ayedun, B. 2014. Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. Journal of Development and Agricultural Economics.6 (2), pp. 67-75

Acharya, A.S, Prakash, A, Saxena, P. and Nigam, A., 2013. Sampling: Why and how of it. Indian Journal of Medicinal Specialties. 4(2): .330-333

Adedoyin A O, Shamsudin M N, Radam A, and AbdLatif I., 2016. Effect of improved high yielding rice variety on farmer's productivity in Mada, Malaysia. International Journal of Agricultural Sciences and Veterinary Medicine 4: 39–52.

Agarwal, B. and Herring, R. 2013. Food security, productivity, and gender inequality. The Oxford handbook of food, politics, and society, 861, pp.273-301.

Aguilar, A., Carranza, E., Goldstein, M., Killic, T. and Oseni, G., 2015. Decomposition of gender differentials in agricultural productivity in Ethiopia. Agricultural Economics, 46(3), pp. 311 – 334.

Akpan, N.S., 2015. Women and rural development in Nigeria: Some critical issues for policy consideration. Social sciences, 4(5), pp.110-118.

Akpan, S.B., Nkanta, V.S. and Essien, U.A., 2012. A double-hurdle model of fertilizer adoption and optimum use among farmers in southern Nigeria. Tropicultura, 30(4). pp.249-253

Akudugu M. A., Guo E., Dadzie S.K. 2012. Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? Journal of Biology, Agriculture and Healthcare, 2, (3): 2224-3208

Altalb, A.A.T., Filipek, T. and Skowron, P. 2015. The role of agricultural extension in the transfer and adoption of agricultural technologies. Asian Journal of Agriculture and Food Sciences, 3(5).ISSN 2321-1571

Aneani, F., Anchirinah, V.M., Owusu-Ansah, F. and Asamoah, M. 2012. Adoption of some cocoa production technologies by cocoa farmers in Ghana. Sustainable Agriculture Research, 1(1), p.103.

Annor-Frempong, C., 2013. The influence of intervening variables and subjective norms on the adoption behaviour of small scale farmers in South Africa and Lesotho (Doctoral dissertation, University of Pretoria).

AIS Annual Report. 2004. Department of Field Service, Ministry of Agriculture and Food Security, Maseru, Lesotho.

Aregu, L., Puskur, R. and Bishop-Sambrook, C. 2011. The role of gender in crop value chain in Ethiopia. Paper presented at the Gender and Market Oriented Agriculture (AgriGender 2011) Workshop, Addis Ababa, Ethiopia, 31st January-2nd February 2011. Nairobi, Kenya

Arthi, V., De Weerdt, J., Beegle, K., and Palacios-Lo´pez, A., 2016. Not your average job: Measuring farm labour in Tanzania. Development Economics, Development Data Group, WPS7773

Bahua, M.I., 2016. Assessing professional competencies of agricultural extension workers: A case study of Indonesian's agribusiness sector. International Journal of Agriculture Innovations and Research, 4(4), pp.743-746

Bamire, A.S., Abdoulaye, T. and Sanogo, D., 2012. Determinants of improved maize adoption in Nigeria: are they the same for poor and well endowed households? Ife Journal of Agriculture, 25(1), pp.83-100.

Bureau of Statistics. 2019. Lesotho District Profiles: Agricultural production survey crop. Maseru, Lesotho.

Beyene, A.D. and Kassie, M., 2015. Speed of adoption of improved maize varieties in Tanzania: An application of duration analysis. Technological Forecasting and Social Change, 96, pp.298-307.

Bluman, G. 2012. Elementary statistics: a step by step approach / Allan Bluman – 8th edition.

Bolarinwa, O.A., 2015. Principles and methods of validity and reliability testing of questionnaires used in social and health science researches. Nigerian Postgraduate Medical Journal, 22(4), p.195.

CGIAR (Consultative Group on International Agricultural Research). 2014. Improved maize varieties and poverty in rural Ethiopia standing panel on impact assessment (SPIA).

Challa, M. T., and Mahendran, A. 2015. Gender difference and its impact on agricultural productivity: The case of Sheko District in Bench Maji Zone of SNNP, Ethiopia. International Journal of Current Research, 7(11), 22938–22942.

Challa, M., and Tilahun, U., 2014. Determinants and impacts of modern agricultural technology adoption in west Wollega: the case of Gulliso district. Journal of Biology, Agriculture and Health care, 4(20), 63-67.

Chongtham, I. R., Bergkvist,G.,Watson,C. A.,Sandström,E.,Bengtsson,J., and Öborn,I., 2017.Factors influencing crop rotation strategies on organic farms with different time periods since conversion to organic production. Biological Agriculture and Horticulture, 33(1), 14–27.

Christinck, A., Weltzien, E., Rattunde, F., and Ashby, J., 2017. Gender Differentiation of Farmer Preferences for Varietal Traits in Crop Improvement: Evidence and Issues. CGIAR Gender and Agriculture Research Network; CGIAR System Management Office and International Centre for Tropical Agriculture (CIAT), Cali, Colombia Working Paper No. 2.

Creswell, J.W., 2014. A concise introduction to mixed methods research. Sage publications.

Croppenstedt, A., Goldstein, M. and Rosas, N., 2013. “Gender and agriculture: Inefficiencies, segregation, and low productivity traps”, Policy Research Working Paper, No.6370, The World Bank.

Daniel, J., 2012. Choosing the type of probability sampling. Sampling essentials: Practical guidelines for making sampling choices, pp.125-175.

Danso-Abbeam, G., Bosiako, J.A., Ehiakpor, D.S. and Mabe, F.N., 2017. Adoption of improved maize variety among farm households in the northern region of Ghana. Cogent Economics & Finance, 5(1), p.1416896.

Das, B., Deventer, F. V., Wessels, A., Mudenda, G., Key, J., and Ristanovic, D. 2019. Role and challenges of the private seed sector in developing and disseminating climate-smart crop varieties in eastern and southern Africa. In the Climate-Smart Agriculture Papers (pp. 67-78). Springer, Cham.

De la O Camposas, A.P., Covarrubias, K. A., and Patron, A. P. 2016. How does the choice of the gender indicator affect the analysis of gender differences in agricultural productivity? Evidence from Uganda. World Development, 77(C), 17–33.

Doss, C. R. 2018. Women and agricultural productivity: Reframing the issues. Development Policy Review, 36, 35–50.

FAO (Food and Agriculture Organization).2011. The state of food and agriculture. Women in Agriculture: Closing the gender gap for development. ISBN 978-92-5-106768-0,

FAO 2011. The state of food and Agriculture, Women in agriculture, ISSN 0081-4539 FAO (2012) OECD-FAO Agricultural Outlook, 2012-2021

F.A.O, 2014. Gender-specific approaches, rural institutions and technological innovations: identifying demand and supply side constraints and opportunities in access, adoption and impact of agricultural technological innovations. Rome, Italy.

FAO, 2016. Seed security assessment - Lesotho

Folbre N. The care economy in Africa: Subsistence production and unpaid care. Journal of African Economies 2013; 23(1):i128–i156.

Fricker, R., 2012. Target Populations, Sampling Frames, and Coverage error. Naval Postgraduate School Monterey, California. Management Among Supermarkets in Nukuru Town, Kenya.

Gatzweiler, F.W., and Von Braum, J. 2016. Innovation for marginalized smallholder farmers and development: an overview and implication for policy and research. Technological and institutional innovations for marginalised smallholders in agricultural development, 1-22

Gaya, H.T., Tegbaru, A., Bamire, A.S., Abdoulaye, T. and Kehinde, A.D., 2017. Gender differentials and adoption of drought tolerant maize varieties among farmers in northern Nigeria. European Journal of Bussiness and Management, 9(5), pp 81-87

Gebre G.G., Isoda, H., Rahut D.B., Amekawa, Y., and Nomura, H., 2019, September. Gender differences in the adoption of agricultural technology: The case of improved maize varieties in Southern Ethiopia. In women' studies international forum (vol.76, pp, and 1-11). Pergamon

Gebre, G.G., Isoda, H., Rahut, D. B., Amekawa, Y. and Nomura, H., 2021. Gender difference in agricultural productivity: Evidence from maize farm households in Southern Ethiopia. Geojournal, 86 (2) pp.843-864.

Gecho, Y. and Punjabi, N.K., 2011. Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia.Rajasthan Journal of Extension Education,19(1), pp.1-9.

Giné, X., and Yang, D. 2008. Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi. Washington DC. Development Economics Research Group, World Bank, 2008.

Gondwe, G. 2020. How 'Qualitable'Is Qualitative Research in Communication Studies? Examining the Pragmatic Use and Acceptance in Media Studies. Examining the Pragmatic Use and Acceptance in Media Studies (March 27, 2020).

Gunaratna, N., Bosha, T., Belayneh, D., Fekadu, T., and De Groote, H., 2016. Women's and children's acceptance of biofortified quality protein maize for complementary feeding in rural Ethiopia. J. Sci. Food Agric. 96 (10), 3439–3445.

Gwimbi, P., 2017. Mainstreaming national adaptation programmes of action into national development plans in Lesotho: lessons and needs. International Journal of Climate Change strategies and Management. Department of Environmental Health, National University of Lesotho, Maseru, Lesotho.

Hailu, B. K., Abrha, B. K., and Weldegiorgis, K. A. 2014. Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. International Journal of Food and Agricultural Economics (IJFAEC), 2(1128–2016– 92058), 91–106.

Hall, B.H. and Khan, B., 2002. Adoption of new technology, new economy handbook. California: Berkeley University.

Heale, R. and Twycross A., 2015. Validity and Reliability in quantitative studies. Evidence – based nursing, 18(3), pp. 66 – 67

Hendriks, S. 2014. Food Security in South Africa: Status quo and policy imperatives. Agrekon, 53(2), 1-24.

Henry, K., Julius, M., Franklin, S., Kai, M., and Moses, S. 2012. Improved Legume Seed Demand Systems In Central Malawi: International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Herell, S., and Krishnamn, P. 2007. Poverty and productivity in female-headed households in Zimbabwe. Journal of Development Studies, 43(8), 1351-1380.

High Level Panel of Experts, 2017. Nutrition and Food Systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee of World Food Security, Rome, Italy

Hopestone, K.C., 2014. The role of ICTs in agricultural production in Africa. Journal of Development and Agricultural Economics, 6(7), pp.279-289.

Houssou N, and Manfred Z., 2011. To target or not to target? The costs, benefits, and impacts of indicator-based targeting. Food Policy.

Huyer, S., 2016. Closing the gender gap in agriculture. Gender, Technology and Development, 20(2), pp.105-116.

Kariyasa, K., and Dewi, A. 2011.Analysis of Factors Affecting Adoption of Integrated Crop Management Farmer Field School (Icm-Ffs) in Swampy Areas. International Journal of Food and Agricultural Economics 1(2): pp 29-38

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F. and Mekuria, M., 2013. Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. Technological forecasting and social change, 80(3), pp.525-540.

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P. and Erenstein, O., 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. Land use policy, 42, pp.400-411.

Kesmodel, U.S., 2018. Cross sectional studies – what are they good for?. Acta obstetricia et gynecologica Scandinavica, 97(4), pp.388-393.

Kumar, G., Engle, C. and Tucker, C. 2018. Factors driving aquaculture technology adoption. Journal of the world aquaculture society, 49(3), pp.447-476.

Lavison, R. 2013. Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, Msc Thesis, Accra Ghana.

Lesotho Country Analysis Final Report. 2017. Lesotho Country Analysis: Working Document Final Draft. Maseru, Lesotho.

Letsie, M.M.A., 2015. An Assessment of Place Vulnerability to Natural Hazards in South – Western Lesotho (Quthing and Mohales'hoek Districts) (Doctoral dissertation, University of the Witwatersrand, Faculty of Science, School of Geography, Archaeology & Environmental Studies).

Liberio J. 2012. Factors contributing to adoption of sunflower farming innovations in mlali ward, mvomero district, morogoro region – Tanzania, a dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Education and Extension of Sokoine University of Agriculture. Morogoro, Tanzania.

Lio, M., and Liu, M. C., 2006. ICT and agricultural productivity: evidence from cross- country data. Agricultural Economics, 34(3), 221-228.

Loevinsohn M, Sumberg J, Diagne A 2012 under what circumstances and conditions does adoption of technology result in increased agricultural productivity? Protocol. London: EPPI Centre, Social Science Research Unit, Institute of Education, University of London.

Manda, DK, Mwakubo S. 2014. Gender and economic development in Africa: An overview. Journal of African Economies;23(1):i4–i17.

Manfred, C., Rubin, D., Allen, A., Summerfield, G., Colverson, K. and Akeredolu, M., 2013. Reducing the gender gap in agricultural extension and advisory services: How to find the best fit for men and women farmers. Meas Brief, 2, pp.1-10.

Masupha, P. Jankielsohn, A. and Mohase, L. 2018 assessment of cultivation practices of wheat and knowledge of Russian wheat aphid (diuraphis noxia), in Mokhotlong and Thaba Tseka districts of Lesotho. International Journal of Agricultural Extension and Rural Development Studies Vol.5, No.3, pp.13-23.

Masimba, F. and Zuva, T. 2021. Individual Acceptance of Technology: A Critical Review of Technology Adoption Models and Theories. Indiana Journal of Humanities and Social Sciences, 2(9), pp.37-48.

Meijer, S.S., Catacutan, D., Ajayi, OC., Sileshi, G., and Nieuwenhuis, M. 2015. The role of knowledge, attitudes, and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in Sub-Saharan Africa. International journal of agricultural sustainability, 13(1), 40-54.

Mignouna, B., Manyong, M., Rusike, J., Mutabazi, S., and Senkondo, M. 2011. Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya: AgBioforum, 14(3), 158-163.

Mgendi, G., Mao, S. and Qiao, F., 2022. Does agricultural training and demonstration matter in technology adoption? The empirical evidence from small rice farmers in Tanzania. Technology in Society, p.102024.

Mofolo, S.P., 2021. Evaluating biological nitrogen fixation of bean and nitrogen use efficiency of maize cultivars of improving crop productivity and soil fertility in Lesotho (Doctoral dissertation)

Mohlatsane, M., Chabana, M., and Ts'iame, P. 2009. Ministry of Agriculture and Food Security. Performance Audit Report on Crop Production, Lesotho.

Mokotjo, W. 2009. Evaluation of agricultural information service (AIS) in providing information to farmers in Maseru district, Lesotho. MLIS Dissertation, University of Botswana, Gaborone.

Mokotjo, W., and Kalusopa, T. 2010. Evaluation of the agricultural information service (AIS) in Lesotho. International Journal of Information Management, 30(4), 350-356.

Molatoli, J.T. and Li, X., 2016. Development evaluation of Lesotho agricultural input subsidy policy based on rural household's food security and access to inputs: Evidence from Mohale's Hoek District. African Journal of Agricultural Research, 11(16), pp.1411-1420.

Morojele M. and Sekoli M. 2016. Trend Analysis of Maize Production in Lesotho and Its Distribution Among the Ecological Zones. European Journal of Agriculture and Forestry Research Vol.4, No., pp.1- 7, March 2016.

Mottaleb KA, Kruseman G and Erenstein O, 2018. Determinants of maize cultivation in a land-scarce rice-based economy: The case of Bangladesh. Journal of Crop Improvement 32(4): 453–76. National Bureau of Statistics (NBS), 2017. National Panel Survey Wave 4, 2014–2015. Dar es Salaam, Tanzania: National Bureau of Statistics.

Motsa, K.A., 2014. Is Women s Increased Accessibility to Land a Path to Sustainable Development? The Case of Urban Maseru, Lesotho. Journal of Social and Development Sciences, 5(4), pp.176.176-181.

Moyo.S. 2016. Family farming in sub Saharan Africa: its contribution to agriculture, food security and rural development (No.150). Working paper.

Munyua, H. 2000. Application of ICTs in Africa's agricultural sector: A gender perspective. Gender and the information revolution in Africa, 85-124.

Musikoyo, K. M. 2012. Adoption of Information Communication Technology among Farmers: A case Study of Rural Kenya (Doctoral dissertation, United States International University-Africa).

Mwangi, M. and Kariuki, S. 2015. Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. Journal of Economics and sustainable development, 6(5). pp, 209-217.

Neway, M.M. and Zegeye, M.B., 2022. Gender differences in the adoption of agricultural technology in North Shewa Zone, Amhara Regional State, Ethiopia. Cogent Social Sciences, 8(1), p.2069209.

Njuki, M., Kihiyo, M., Oktingati, A., and Place, F. (2006). Productivity differences between male and female managed farms in the Eastern and Central Highlands of Kenya.

Nhlengethwa, S., Matchaya, G., Greffiths, J. and Fakudze, B., 2020. Maize flour price trends in rural districts and urban districts of Lesotho under COVID-19.: Covid-19 Bulletin.

Noordzij, M., Dekker, FW. Zoccali, C. and Jager, K.J. 2011. Sample size calculations. Nephron Clinical Practice, 118(4), pp.c319-c323.

Obayelu, A. E., Okuneye, P. A., Shittu, A. M., Afolami, C. A., and Dipeolu, A. O. 2016. Determinants and perceived effects of adoption of sustainable improved food crop technologies by smallholder farmers along the value chain in Nigeria. Journal of Agriculture and Environment for International Development (JAEID), 110(1), 155 -172.

O'Brien, C., Gunaratna, N.S., Gebreselassie, K., Gitonga, Z.M., Tsegaye, M., and De Groote, H., 2016. Gender as a cross-cutting issue in food security: the NuME project and quality protein maize in Ethiopia. World Med. Health Policy 8, 263–286.

Onyeneke, R.U. 2017. Determinants of adoption of improved technologies in rice production in Imo State, Nigeria. African Journal of Agricultural Research, 12(11), pp.888-896.

Osen, G., Corral, P., Goldstein, M. and Winters, P. 2015. Explaining gender differentials in agricultural production in Nigeria. Journal of Agricultural Economics, 46(3):285-310.

Paramaiah, C., 2021. Gender and multidimensional poverty in Lesotho. Psychology and Education journal, 57(9), pp. 6522-6534.

Patil, B. and Babus, V.S., 2018. Role of women in agriculture. *Int J Applied Res*, *4*(12), pp.109-114.

Peterman, A., Behrman, A. and Quisumbing, R. 2010. A review of empirical evidence on gender differences in nonland agricultural inputs, technology, and services in developing countries. IFPRI Discussion Paper 00975. Poverty, Health, and Nutrition Division (PHND). Washington, D.C.: International Food Policy Research Institute.

Quisumbing, A.R., Meinzen-Dick, R., Raney, T.L., Croppenstedt, A., Behrman, J.A. and Peterman, A., 2014. Closing the knowledge gap on gender in agriculture. In Gender in agriculture (pp. 3-27). Springer, Dordrecht.

Rantšo, T.A. and Seboka, M., 2019. Agriculture and food security in Lesotho: Government sponsored block farming programme in the Berea, Leribe and Maseru Districts. Cogent Food & Agriculture, 5(1), p.1657300.

Rao, N. H. 2007. A framework for implementing information and communication technologies in agricultural development in India. Technological Forecasting and Social Change, 74(4), 491-518.

Raut, N., K. B. Sitaula, A. Vatn, and S. G. Paudel. 2011. "Determinants of Adoption and Extent of Agricultural Intensification in the Central Mid-Hills of Nepal." Journal of Sustainable Development 4 (4): 47–60. doi:10.5539/jsd.v4n4p47.

Ragasa, C., Berhane, G., Tadesse, F., and Taffesse, A. 2012. Gender differntials in access to extension services and agricultural productivity. ETHIOPIA Strategy Support Program II, Working Paper.

Reddy, P.P. 2017. Crop Rotation. In Agro-ecological Approaches to Pest Management for Sustainable Agriculture (pp. 229-242). Springer, Singapore.

Regoniel, P.A.2015.Conceptual framework : A step by step guide on how to make one. Simply Educate. me

Ross KL, Zereyesus YA, Shanoyan A, and Amanor-Boadu V. 2015. The health effects of women') empowerment: Recent evidence from northern Ghana. International Food and Agribusiness Management Review 2015; 18(1):127–44.

Ruel, M.T., Quisumbing, A.R., and Balagamwala, M. 2018. Nutrition-sensitive agriculture: what have we learned so far? Glob. Food Security 17, 128–153. https://doi.org/10. 1016/j.gfs.2018.01.002.

Saleem, Farzand A. J., Muhammad I. Q., and Latifullah K. 2011. Linking financial market and farm & farmers' features for adoption of new farm technology, Journal of Research 27, 1: 69-76.

Salim, S.A., Sedera, D., Sawang, S., Alarifi, A.H.E. and Atapattu, M. 2015. Moving from evaluation to trial: How do SMEs start adopting cloud ERP?. *Australasian Journal of Information Systems, 19*.

Sekoli, M.M.S. and Morojele, M.E., 2016. Sorghum productivity trends and growth rate for Lesotho. Global Journal of Agricultural Research, 4(1), pp.52-57.

Sharma, P. B. 2013. Measuring the price of labour in agricultural economics: The shadow wage rate. Economic Journal of Development Issues, 15–16(1–2), 24.

Sharma, G., 2017. Pros and cons of different sampling techniques. International journal of applied research, 3(7), pp.749-752.

Swab K, Porter M .2009. Global Competitiveness Report 2008-2009 The world Economic Forum.

Sinyolo, S. 2020. Technology adoption and household food security among rural households in South Africa: the role of improved maize varieties. Technology in society, 60,101214.

Sisay, D., Jema, H., Degye, G., and Abdi-Khalil, E. 2015. Speed of improved maize seed adoption by smallholder farmers in Southwestern Ethiopia: Analysis using the count data models. Journal of Agricultural Economics, Extension and Rural Development, 3(5), 276–282.

Smale, M., and Mason, N. 2014. Hybrid seed and the economic wellbeing of smallholder maize farmers in Zambia. Journal of Development Studies, 50(5), 680-695.

Swiss Agency for Development and Cooperation (SDC). 2015. Gender Analysis of Maize Post-Harvest Management in Kenya: A Case Study of Nukuru, Naivasha and Embu Districts. Federal Department of Foreign Affairs.

Taherdoost. H. 2016. Sampling methods in research methodology; how to choose a sampling technique for research. How to Choose a Sampling Technique for Research. (August 10. 2016).

Tanellari, E., Kostandini, G., Bonabana-Wabbi, J. and Murray, A. 2014. Gender impacts on adoption of new technologies: the case of improved groundnut varieties in Uganda. African Journal of Agricultural and Resource Economics, 9(311-2016-5619), pp.300-308.

Tanumihardjo, S.A., McCulley, L., Roh, R., Lopez-Ridaura, S., Palacios-Rojas, N. and Gunaratna, N.S. 2020. Maize agro-food systems to ensure food and nutrition security in reference to the Sustainable Development Goals. Global Food Security, 25, p.100327.

Tavakol, M. and Dennick, R. 2011. Making sense of Cronsbach's alpha. International journal medical education, 2, p.53.

Theofanidis, D., and Fountouki, A. 2018. Limitations and delimitations in the research process. Perioperative Nursing-Quarterly scientific, online official journal of GORNA, 7(3 September-December 2018), 155-163.

Tsige, M., Synnevåg, G. and Aune, J.B. 2020. Gendered constraints for adopting climate-smart agriculture amongst smallholder Ethiopian women farmers. Scientific African, 7, p.e00250.

Uaiene, R., Arndt, C., and Masters, W. 2009. Determinants of Agricultural Technology Adoption in Mozambique. Discussion papers No. 67E.

Wei, W., Sarker, T., Roy, R., Sarkar, A. and Ghulam Rabbany, M. 2021. Women's empowerment and their experience to food security in rural Bangladesh. Sociology of Health & Illness, 43(4), pp.971-994.

World Bank. 2014. Levelling the field: Improving opportunities for women farmers in Africa. Washington, DC: World Bank.

Yahya, H.P. and Xiaohui, Z. 2014. Constraints to women smallholder farmers' efforts in ensuring food security at household level: A case of Msowero ward of Morogoro region Tanzania. International Journal of Economics and Finance, 6(5), p.47.

Zereyesus YA. 2017. Women's empowerment in agriculture and household level health in northern Ghana: A capability approach. Journal of International Development 2017; 29:899–918.

APPENDIX

QUESTIONNAIRE FOR FARMER SURVEY

The major objective of this study is to investigate the gender gap in agricultural production and productivity with focus on technology adoption of maize farm households in Quthing, Lesotho. The results of this study might influence the designing of programmes that are gender responsive thereby contributing to overall agricultural development and poverty alleviation in Lesotho.

Your answers to this questionnaire are strictly confidential and are only for the purposes of this study. Please be as honest as possible.

Name of community..
Date...

(I) Demographic/ Socio-economic characteristics of the farmers

1. Name of respondent..

2. Age of respondent < 30 year ☐ 30-40 years ☐ 41-51 years ☐ >51 ☐

3. Sex: Male ☐ Female ☐

4. Marital status: Single ☐ Married ☐ Divorced ☐ Separated ☐

5. Religion: Christianity ☐ Traditional ☐ Islam ☐

Other ☐ Specify…………………………………………

6. Educational level:

No education ☐ Primary ☐ Secondary ☐ Tertiary ☐

7. How long have you been active in farming? ....

8. How many are you in your family? ……………

(a) Is there any hired labourers who assist you in your farm work? Yes ☐ No ☐

(b) If yes how many labourers often assist you in your farm work? ....

9. Do you have other sources of off farm income? Yes ☐ No ☐

If yes, state them (a)……………………. (b)……………………… (c)………………

10. State the number of livestock that you have…………………

Cattle……Sheep ……Goats……Horses……Donkeys……Pigs……Chickens………

Other (Specify)………………………………………………………………..

11. What type of land tenure system do you practice?

Share cropping ☐ Outright purchased ☐ Family land ☐ Lease ☐

12. What is the size of your farming land? .... (Acres)

13. How much area allocated for maize production? ……………… (Acres)

(II) Determining the level of adoption for male and female farmers on improved technology

1. Have you heard or read about climate change? Yes ☐ No ☐

(a) If yes where have you read or heard about it? Radio ☐ Newspaper ☐ Extension agent ☐

Internet ☐ Other ☐ Specify………………………………..

2. Do you adapt to climate change? Yes ☐ No ☐

3. Do you practice conservation agriculture (CA)? Yes ☐ No ☐

(a) If yes how do you sow improved maize seed? Manual Seeding ☐ Planters ☐

Other ☐ Specify………………………

4. What do you use as a soil cover between the rows?

Crop residue ☐ Mulch from outside field ☐ Cover crops ☐

Other ☐ Specify………………………

5. Do you rotate crops on your field? Yes ☐ No ☐

6. Do you practice row planting? Yes ☐ No ☐

(a) If yes what do you use to make rows? Ox drawn planter ☐ Tractor ☐

Other ☐ Specify…………………..

7. Do you plant improved maize varieties? Yes ☐ No ☐

(a) If yes which improved maize seeds do you plant?

DKC 7372 ☐ Pannar ☐ SNK 2778 ☐ SAHARA ☐

Other ☐ Specify ………………………………

8. Do you practice weeding on your field? Yes ☐ No ☐

(a) If yes do you apply herbicides as a weed control measure? Yes ☐ No ☐

(b) Which other methods do you use to control weeds?

Hand pulling ☐ Hoeing ☐ Ox drawn cultivator ☐ Other ☐

(Specify) ………………………………….

9. Do you control insects on your field? Yes ☐ No ☐

(a) If yes, do you apply pesticides as an insect control measure on your field? Yes ☐ No ☐

(b) Which other methods of insect control do you use?

Hand picking ☐ Natural insect enemies ☐ Sanitation ☐ Others ☐

Other (Specify)…………………………………….

10. Do you apply irrigation system in your maize farm? Yes ☐ No ☐

(a) If yes which irrigation method, do you practice?

Surface ☐ Sprinkler ☐ Drip ☐ Sub -Surface ☐

Other ☐ (Specify)…………………………………………..

11. Do you apply fertilizer on your field? Yes☐ No☐

(a) If yes what do you use to improve soil fertility?

Kraal manure ☐ Compost ☐ Chemical fertilizer ☐ Other☐

(Specify)………………………

(II) Factors influencing the adoption of improved technologies

1. Do you have access to credit facilities? Yes☐ No ☐

(a) If yes where do you access credit?

Bank ☐ farmers' association ☐ Corporative ☐ Other ☐ (Specify)…………….

2. Do you participate in field days? Yes ☐ No ☐

3. Do you have access to extension services? Yes☐ No ☐

(a) If yes, how frequently do you have contact with extension agents?

Weekly ☐ Monthly ☐ Quarterly ☐ Annually ☐

(b) Do you have confidence in the skills and competencies of extension staff?

Yes ☐ No ☐

4. Are you a member of any farmer group in your community? Yes ☐ No ☐

5. Do you participate in farm trials? Yes ☐ No ☐

6. Do you participate in farmer trainings? Yes☐ No ☐

7. Are you self-sufficient in maize production? Yes ☐ No ☐

(a) On average, how many tons of maize do you normally harvest every year? ....

8. How long is the distance you walk to the maize seed dealer (walking minutes)? …………………

9. How long is the distance you walk to the market (walking minutes)? ………….

10. How long is the distance you walk to Agriculture extension office (Walking minutes)? ....

11. Do you have access to ICT? Yes ☐ No ☐

(a) If yes which of the following devices do you have?

Radio ☐ Smart phone ☐ Television ☐

Other ☐ (Specify)…………………………