

**ADOPTION OF QUALITY PROTEIN MAIZE TECHNOLOGY IN TANZANIA:
THE CASE OF NORTHERN ZONE**

BY

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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2010**ABSTRACT**

Quality protein maize (QPM) contains nearly twice as much usable protein more than normal maize. Since 2001 QPM varieties have been disseminated in the country to small scale farmers for production and adoption. The thrust of this study was to determine the adoption of (QPM) technology and examine the factors that influence its adoption by farmers. Primary data was collected from randomly selected 120 smallholder maize farmers in four villages of northern Tanzania (Babati and Hai) districts. Data collected from formal and informal surveys were analysed using descriptive and quantitative methods to assess the rate of adoption. Logit model was used to determine factors that influence adoption of QPM technology in the study area. Study findings revealed that the rate of adoption of QPM technology was 25%. QPM seed unavailability was the major reason for not adopting reported by nonadopters. The regression results indicated that education of the household head, farmers' participation on demonstration trials, attendance to field days, and number of livestock owned positively influenced the rate of adoption of QPM technology. Lack of special QPM product market and agricultural production credit facilities negatively influenced the likelihood of farmers to adopt QPM technology in the study area. The study therefore indicated that the adoption rate of QPM technology was low across the study area. It is therefore recommended that the Ministry of Agriculture to put efforts to ensure efficient input output linkage for QPM production. Maize breeders incorporate a special marker in QPM that can differentiate it from normal maize. The

formal credit system to address the agriculture credit constraints of small-scale farmers, and make it available for agricultural production.

DECLARATION

I, THERESIA GREGORY do declare to the Senate of Sokoine University of Agriculture that the work presented here is my own, and has not been submitted for a higher degree award in any other University.

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The above declaration is confirmed

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DEDICATION

This work is first dedicated to Jesus Christ, secondly to my lovely parents Leopold Gregory and Helena Epimaki. Thank you for your love. Your love has been of valuable contribution to my success in education.

TABLE OF CONTENTS

<i>ABSTRACT</i>	ii
<i>DECLARATION</i>	iii
<i>COPYRIGHT</i>	iv
<i>ACKNOWLEDGEMENTS</i>	v
<i>DEDICATION</i>	vii
<i>TABLE OF CONTENTS</i>	viii
<i>LIST OF TABLES</i>	xii
<i>LIST OF FIGURES</i>	xiii
<i>LIST OF APPENDICES</i>	xiv
<i>LIST OF ABBREVIATIONS AND SYMBOLS</i>	xv
<i>CHAPTER ONE</i>	1
<i>1.0 INTRODUCTION</i>	1
<i>1.1 Background Information</i>	1
<i>1.2 Problem Statement and Justification</i>	3
<i>1.3 Objectives of the Study</i>	4
1.3.1 General objective.....	4
1.3.2 Specific objectives.....	4
<i>1.4 Hypotheses</i>	4
<i>1.5 Organization of the Study</i>	5

CHAPTER TWO.....	6
2.0 LITERATURE REVIEW.....	6
2.1 Concepts of Adoption.....	6
2.2 Adoption of New Technologies.....	6
2.3 Different Perspectives for Technology Adoption.....	7
2.4 Variety Attributes, Farmers’ Preferences and Technology Adoption.....	8
2.5 Information and Incentive to adopt new Technology.....	10
2.6 Institutions, Resources Availability and Technology Adoption.....	11
2.7 Adoption Theories.....	14
2.7.1 Traditional approach.....	14
2.7.2 The 5-Stage or “Classical” adoption process.....	14
2.7.3 The theory of reasoned action.....	15
2.7.4 The Innovation – decision process model.....	16
2.8 Methodologies Employed in Adoption Studies.....	18
 CHAPTER THREE.....	 20
3.0 METHODOLOGY.....	20
3.1 Overview.....	20
3.2 Description of the Study Area.....	20
3.2.1 Location.....	20
3.2.2 Climate and topography.....	20
3.2.3 Population.....	20
3.2.4 Land use.....	21
3.3 Research Design.....	22

3.4	Sample Size and Sampling Procedures.....	22
3.5	Data Collection.....	23
3.6	Data Analysis.....	24
3.7	Data Limitation.....	24
3.8	Specification and Estimation of the Logit Model.....	25
3.9	Factors Influencing Adoption of QPM Technology.....	25
 CHAPTER FOUR.....		26
4.0	RESULTS AND DISCUSSION.....	26
4.1	Overview.....	26
4.1.1	Demographic Characteristics of Adopters and nonadopters.....	26
4.1.2	Distribution of household head by gender.....	27
4.2	Socio-economic Characteristics of Household.....	28
4.2.1	Farm size.....	28
4.2.2	Crops grown.....	29
4.2.3	Off farm activities.....	30
4.2.4	Livestock owned.....	31
4.3	Institutional Characteristics.....	31
4.3.1	Extension services.....	32
4.3.2	Access to credit.....	32
4.3.3	Membership to farmers' organization /group.....	33
4.4	Adoption of QPM Technology.....	34
4.4.1	Awareness and spread of QPM.....	34
4.4.2	Source of QPM technology information.....	35

4.4.3	Rate of adoption.....	36
4.4.4	Initial Source of QPM seeds.....	36
4.4.5	Adopters of QPM in 2007/8 cropping season.....	37
4.4.6	Source of QPM seed for 2007/08 cropping season.....	38
4.4.7	Reasons for not adopting.....	38
4.4.8	Adoption intensity/extent of QPM technology adoption.....	39
4.4.9	Uses of QPM in the study area.....	40
4.4.10	Consumption of QPM.....	40
4.4.11	QPM Marketing.....	41
4.4.12	Farmers' opinions on how to improve adoption.....	42
4.5	Logistic model estimates.....	43
 CHAPTER FIVE.....		47
5.0 CONCLUSION AND RECOMMENDATIONS.....		47
5.1 Conclusion.....		47
5.2 Recommendations.....		48
 REFERENCES.....		49
APENDICES.....		62

LIST OF TABLES

Table 1:	Distribution of the sample.....	23
Table 2:	Household characteristics of the sample.....	27
Table 3:	Household heads distribution by gender.....	28
Table 4:	Farm size (ha) of adopters and nonadopters.....	28
Table 5:	Important cash crops grown in Babati district.....	29
Table 6:	Important food crops grown.....	29
Table 7:	Off-farm activities.....	30
Table 8:	Number and type of livestock owned.....	31
Table 9:	Membership to farmers' organization, access to extension services, credit, on farm demonstrations and farmers field days.....	33
Table 10:	Awareness of QPM.....	35
Table 11:	Source of QPM technology information.....	35
Table 12:	Adoption rate of QPM technology.....	36
Table 13:	Initial sources of QPM seeds for adopters (n=30).....	37
Table 14:	Adopters in Babati and Hai districts in 2007/08 Cropping season.....	37
Table 15:	Sources of QPM seed for 2007/08 cropping season.....	38
Table 16:	Major reasons for not adopting (n=90).....	38
Table 17:	Area under QPM.....	39
Table 18:	Uses of QPM.....	40
Table 19:	Consumption of QPM.....	40
Table 20:	Maize Marketing.....	41
Table 21:	Buyers of QPM.....	41
Table 22:	QPM price perception.....	42
Table 23:	Farmers Suggestions for Enhancing the Uptake of QPM Technology.....	42
Table 24:	Logit model results for factors influencing the adoption of QPM technology.....	44

LIST OF FIGURES

Figure 1: Map of Northern Zone of Tanzania showing Hai and Babati Districts.....21

LIST OF APPENDICES

Appendix 1: Survey questionnaire.....	62
Appendix 2: Importance of maize in the diet of individuals in selected African countries.....	71
Appendix 3: Normal endosperm flint type maize (A), normal endosperm dent type maize (B), opaque-2 maize (C) and Quality Protein Maize (D).....	72

LIST OF ABBREVIATIONS AND SYMBOLS

BDC	Babati District Council
BRAC	Building Resource Across Community
CBOs	Community Based Organizations
CDF	Cumulative Distribution Function
CIMMYT	International Maize and Wheat Improvement Centre
DALDO	District Agricultural And Livestock Development Offices
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agriculture Organization statistics
GMOs	Genetically Modified Organisms
HDC	Hai District Council
HYV	High Yielding Variety
LISHE-H2	Lishe Hybrid -2
LISHE-HI	Lishe hybrid -1
LISHE-K1	Lishe Composite-1
LMP	Linear Probability model
LPM	Linear probability Model
MUVIMAHA	Muungano wa Vikundi vya Maendeleo Hai.
NARS	National Agricultural Research Systems
OPV	Open Pollinated Variety
QPM	Quality Protein Maize
QPM D	Quality Protein Maize Development
SACCOS	Saving and Credits Cooperative Society
SARI	Selian Agricultural Research Institute
SG2000	SASAKAWA GLOBAL 2000
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package For Social Science

STATA	Data Analysis and Statistical Software for Professionals
TACAIDS	Tanzania commission for AIDS
TDT	Technology Development and Transfer
VICOBA	Village Community Bank

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Maize (*Zea mays* L.) plays a very important role in human and animal nutrition in a number of developed and developing countries worldwide (Prasanna *et al.*, 2001). In Africa, maize supplies at least one fifth of total daily calories and accounts for 17 to 60% of the total daily protein supply of individuals in 12 countries as estimated by FAO food balance sheets (FAOSTAT, 2003).

In Tanzania it is the most important staple food whereby over 80% of the population depends on maize for food and cash income (Ransom *et al.*, 1997). Maize provides 33% of dietary calories and 33% of utilizable protein to the Tanzanian population (Appendix 3). Maize is also used as ingredient of animal feed in livestock production (Kaliba *et al.*, 1998). Maize accounts for 31% of the total food production and constitutes more than 75% of the cereal consumption in the country (Msuya *et al.*, 2008). The main maize producing areas are southern highlands and northern regions.

Normal maize contains limited contents of lysine and tryptophan that are important, amino acids (FAO, 1992; Bressani, 1991). This reduces its protein quality for humans and monogastric animals like pigs.

Forty years ago Mertz and his associates reported that the *opaque -2* (o2) maize mutant with an *opaque -2* (o2) gene increased the content of lysine and tryptophan and decreased leucine (Mertz *et al.*, 1964). The discovery of *opaque -2* (o2) gene triggered intensive

breeding programs at the International Maize and Wheat Improvement Center (CIMMYT) breeders transformed *opaque* –2 (O2) into varieties that have higher nutrition quality, high yields, with appearance of normal maize. This enhanced *opaque* –2 (O2) is called quality protein maize (QPM) (Appendix 4).

Quality protein maize contains nearly twice as much usable protein more than normal maize. Some QPM hybrids contain as much as 13.5% protein (CIMMYT, 2001). The improved QPM populations were released for direct use in the field as open pollinated varieties (OPVs) or in bred lines used in hybrid formation. As a result many cultivars (both OPVs and hybrids) with improved protein quality have been released for temperate, tropical highlands and for subtropical and tropical lowland growing conditions. QPM has widespread adoption in developing countries where maize is a staple food. By 2001, a total of 750,000 hectares were grown in 18 developing countries (FAOSTAT, 2003).

In Tanzania, the National Agricultural Research System (NARS) in collaboration with CIMMYT and SG 2000 released three QPM varieties in 2001, two hybrids Lishe H-1 and Lishe H-2 and one Open Pollinated Variety called Lishe K-1. Since 2001 QPM varieties have been disseminated to small scale farmers for production and adoption.

Rodgers (1962) defines the adoption process as the mental process an individual passes from first hearing about an innovation to the final adoption. Doss (2003) defines adoption as the degree of use of a new innovation in long-run equilibrium when a farmer has full information about the new technology and it's potential.

The adoption of new technology plays a fundamental role in the development process. When an agricultural program introduces a new agricultural technology, such as QPM varieties, the program must be able to evaluate whether the technology has been adopted by farmers after some time. Of equal importance is the need to identify the factors that influence adoption. Therefore, adoption at the farm level describes the realization of farmers' decision to apply a new technology in the production process. As the new technology is introduced, some farmers will experiment with it before adopting. The rate of adoption is defined as the percentage of farmers who have adopted a new technology (Doss, 2003). Research conducted in hilly regions of Nepal and also in other countries indicated that adoption of improved maize varieties depends on socio-economic as well as demographic factors (Ransom *et al.*, 2003; Okuro *et al.*, 2000).

In the extensive reviews of studies on the status of QPM as well as socio-economic factors influencing adoption of QPM technology, no systematic study has been conducted so far to assess factors influencing farmer's decision on adoption of QPM technology in Tanzania. Therefore, the aim of this study was to assess the rate of QPM adoption and identify major socio-economic factors that influence its adoption. This information can be used in documenting whether the introduced technology (QPM) has been accepted by the targeted group and for researchers to design a strategy for scaling up its adoption so as to attain sustainable productivity, improved livelihood, ensured food security, increased rural income and ultimately poverty reduction in the country.

1.2 Problem Statement and Justification

Adoption of technology is an important factor for economic development especially in developing countries. To attract more investment in agricultural research, there is a need for researchers to produce evidence that research and technology dissemination

investments have been competitive (Anandajayasekera, *et al.*, 1996). A study on adoption of improved technology is important because it will generate key indicators for measuring farm level impact so as to improve farming practices.

Bearing in mind the importance of QPM in human diet as nutritional staple food which can be produced and consumed by many households like normal maize there was a need therefore, to understand its status of adoption as well as factors that contribute to its adoption

1.3 Objectives of the Study

1.3.1 General objective

The general objective of this study is to determine the rate of adoption and examine factors that influence farmers' adoption of QPM technology.

1.3.2 Specific objectives

The specific objectives of the study were to:-

- (i) Assess the rate of adoption of QPM in the study area (Hai and Babati districts).
- (ii) Analyze factors affecting the rate of adoption of QPM technology.

1.4 Hypotheses

- i) There is no significant difference in rate of adoption across the area
- ii) There are no significant factors affecting adoption of QPM in the study area.

1.5 Organization of the Study

This study is organized into five chapters. The second chapter presents the review of literature relevant to adoption studies. Chapter three presents the methodology employed in this study which includes the sampling design, data collection tools and analytical techniques. Chapter four presents the findings and discussions of the study results while chapter five followed by chapter five gives the summary of the major findings, concluding remarks and the study recommendations

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concepts of Adoption

Rodgers (1962) defines the adoption process as the mental process an individual passes from first hearing about an innovation to the final adoption. Feder (1980) defines farm level final adoption as the degree to which a new technology is used in the long run when farmers have full information about the technology and its potential benefits. Thus, adoption at the farm level indicates farmers' decision to use new technologies in the production process. Doss (2003) defines adoption as the degree of use of a new innovation in long-run equilibrium when a farmer has full information about the new technology and its potential. Therefore, adoption at the farm level describes the realization of farmers' decision to apply a new technology in the production process. As the new technology is introduced, some farmers will experiment with it before adopting. The rate of adoption is defined as the percentage of farmers who have adopted a new technology. However, the rate of adoption can not be used interchangeably with intensity of adoption which refers to as the level of adoption of a given technology. For instance, the area under new technology measures the intensity of adoption of improved maize seed.

2.2 Adoption of New Technologies

The adoption of new technology plays a fundamental role in the development process. When an agricultural program introduces a new agricultural technology, such as QPM, the program must be able to evaluate whether the technology has been adopted. Of equal importance is the need to identify the factors that influence adoption.

According to Lazaro (2000), three main issues are to be observed in any adoption study. The first is the reason for the observed pattern of adoption and the second is the estimation of the degree of adoption of a new technology which is the proportion of farmers, or harvested area or increased yield due to adopting a technology. The third is the documentation of the degree and scope of adoption of a technology and understanding patterns of adoption that are observed.

2.3 Different Perspectives for Technology Adoption

Recent literature (Uaiene, 2009; Padmaja, *et al.*, 2006; Doss, 2002) has dealt with the differing potential for adoption of technology given gender differences and the complementarity of new technologies with existing ones. Any new technology has different implications to different gender group depending on their responsibilities and ownership of resources (Adesina *et al.*, 2000). Doss (2001) notes that the adoption of technology by women in Africa is especially low and Doss and Morris (2002) suggest that gender affects adoption rates indirectly through access to complementary inputs. Examining household data from rural Ethiopia, Knight *et al.* (2003) find that schooling encourages farmers to adopt innovations.

Rauniyar and Goode (2002) examined the interrelationships among technological practices adopted by maize-growing farmers. Technology adoption requires simultaneous decisions by farmers regarding the use of practices within a package. Understanding interrelationships among practices is important for successful technology planning in developing countries. Leathers and Smale (2001) note that agricultural innovations are often promoted as a package – a new seed variety, a recommended fertilizer application, and other recommended cultivation practices. Nevertheless, many farmers adopt pieces of

the package rather than the whole, in a sequential fashion. In order to learn more about the entire technological package, the farmer may adopt a part of it. Kosarek *et al.* (2001) argue that farmers may be unwilling to invest in a high yielding variety if they are uncertain that the new variety will outperform their current variety. Further, if farmers fear that the potential benefits of the new variety might not be realized because of the uncontrollable factors such as adverse weather, they also do not invest in the new variety even if they are sure that the yields of the new variety are higher.

An individual's assessment of the new technology is subjective and may change over time as a farmer learns more about the technology from neighbors who have already adopted it, the extension service, or the media. Significant adaptation of the technology may be necessary before it performs well in the local production environment. Some farmers may fail to adopt the technology altogether if they determine that it simply does not perform well under their resource conditions, or if the size or type of their farm operation is not suited to the technology (Sunding and Zilberman, 2000).

Uncertainty associated with the adoption of any kind of agricultural technology has two features: first, the perceived riskiness of future farm yield after adoption and second, production or price uncertainty related to farming itself (Kondouri *et al.*, 2006). Therefore technology adoption is taking into account farmers' perceptions about the degree of risk concerning future yield.

2.4 Variety Attributes, Farmers' Preferences and Technology Adoption

According to Joshi and Bauer (2005) farmers have numerous concerns and preferences for variety attributes. Their preferences for the attributes result in variety choice decisions

since they value varieties by considering the attributes they embed. Ultimately, farmers' decisions for variety choice will determine the level of crop diversity.

The adoption of maize varieties may differ depending upon the concerns of the farmers, which are defined by attributes. Farmers can view some attributes as positive and others as negative (Bellon and Risopoulos, 2001). The choice of one variety technology over others is greatly influenced by the balance between these two attributes. Depending on the preferences, resources, and constraints that individual farmers face, a beneficial attribute for one farmer may be a negative one for other, or the balance between positive and negative traits may be acceptable for one farmer but not for another (Ibid.). Lyimo *et al.* (2003) found that early maturity, high yield, and resistance to drought are the attributes preferred by farmers.

According to Pingali *et al.* (2001), farmers may assess a new technology such as crop variety, in terms of a range of attributes, such as grain quality, grain yield, and input requirements. It is established that farmers are also capable of commenting on the design of particular technologies and suggesting changes that would make such technologies and innovations more appropriate for their needs. Joshi and Bauer (2005) revealed that, farmers' preferences are driven by the need for production, tolerance to stress, consumption, marketing and management considerations. There are important variation in the preference for attributes depending upon the economic status of the farmer, geographic locations and his/her farming objective. Most of the experimental work in crop improvement evaluates the maize varieties often using yield as the sole criteria. Most often these varieties have either not been adopted or adopted for a shorter period. Understanding farmers' variety preference saves as an input to future variety development and diffusion.

Thus, for a successful intervention policy has to be informed on: ‘who prefer what kind of variety most?’

Farmers’ perceptions of the technology attributes are important variables in addition to the conventional variables in determining the adoption of modern varieties. As the farmers are the final consumers of the product of agricultural research such as variety and their knowledge of the production system would be valuable input for breeding priority setting, on-farm conservation and the adoption of generated technology (Ibid.).

2.5 Information and Incentive to adopt new Technology

Awareness of the profitability or potential preferential benefits of new technologies is necessary to trigger the diffusion of an agricultural innovation. However, for the adoption process to be sustained, the new technology must be compatible with farmers’ economic resources and supported by institutions responsible for providing inputs and technical advice. Extension visits, attendance at on-farm demonstrations, exposure to mass media, literacy and level of education are some proxies of awareness of new innovations. Innovations that are perceived to be economically compatible with farmers values and resources are often readily adopted (CIMMYT, 2001).

Various studies have been undertaken to identify the factors that influence the adoption of new agricultural technologies (Alary, 2005; Joshi and Bauer, 2005. In almost all of these studies, education was taken as an important explanatory factor that positively affects the decision of households to adopt new agricultural technologies. However, all these studies consider only the educational level of the head of the household and completely disregard the contribution of other members of the household to the adoption decision. Ibid. have

attempted to investigate the factors that affect farmers' adoption of new technologies, such as improved crop varieties and concluded that education has a positive and significant impact on the adoption of modern inputs. Op.cit. concludes that "educated farmers adopt modern technologies earlier and applied them more efficiently throughout the adoption process".

It is commonly hypothesized (Ransom *et al.*, 2003) that greater exposure to appropriate information through various communication channels encourages adoption. However, Rogers (2003) observed that wide availability of mass media (television, radio, magazines) is often limited by cost and literacy. He noted that localized sources of information, such as neighbors and friends, could play a greater role in the diffusion of technology than formal extension services.

The factors associated with monetary incentives are output prices, input prices, and access to markets (Bekele, 2003). The literature review of Shiferaw and Holden (2000) indicates that the impact of the increase or decrease in commodity prices is unclear. This study however anticipates increase in output prices would enhance the investment in improved seed due to farmers' desire for short-term gains. Output prices are expected to positively influence farmer's use of improved seed. It is here assumed that a farmer would only make an effort to go for all the practices if the package is anticipated to "increase the profitability of farming through higher prices" (Ibid.).

2.6 Institutions, Resources Availability and Technology Adoption

Institutional support systems and resources availability plays a major role in technology adoption process. Many studies have been conducted across the globe, showed the

influence of institutional support systems (access to extension services, access to credit, research) and resources availability in technology adoption.

Conley and Udry (2001) argue that farmers learn about new innovations in many ways. They may learn from extension advice, from their own experimentation and from their neighbors' experimentation. On the basis of what they observe their neighbors doing and the success that they have, farmers update their own prior beliefs and it is therefore important that farmers can observe others' success. Gautam (2000) provides an empirical assessment of the farmers' willingness to pay for extension services. Kaliba *et al.* (2000) insist that future research and extension policies should feature farmer participation in the research process and on-farm field trials for variety evaluation and demonstrations.

Zhang *et al.* (2002) examine the adoption of HYV (high yielding variety) seeds in India, suggested that demonstration fields could be used to speed up the adoption of technology. Helder *et al.* (2005) argue that off-farm income can help overcome a working capital constraint or may finance the purchase of a new technology. Ransom *et al.* (2003) observed that off-farm income had a positive effect on adoption, but the data suggest that large changes in off-farm income are needed to create significant increases in adoption of improved OPVs. It is likely that farmers with large off-farm income have one or more family members working outside of the village. Not only would the increased cash allow the family to purchase inputs, but also the individuals working outside the village would have the opportunity to acquire seed and information on new varieties from other areas.

Seed sources and experience of the farmers were the major factors affecting adoption of modern rice varieties in Nepal (Joshi and Bauer, 2005). Seed sources are the key element

in addressing the challenges of responding to farmers' different requirements and preferences, increasing production, and achieving food security. Although the adoption of improved varieties through the formal seed systems has been significant in large parts of the world, the formal systems' share of total seed supply remains low. Informal farmer-to-farmer seed distribution continues to be the prevailing system of seed supply for small scale farmers in many developing countries. These mechanisms are mostly based on traditional social alliances and family relations, and are based in the context of mutual interdependence and trust. However, despite the fact that farmer-to-farmer seed exchange is widely recognized as an important source of seed for vast numbers of farmers, little is known about how these systems function (Ibid). Sunding and Zilberman (2000) find that "new variety adoption is influenced more by institutional and educational considerations".

Croppenstedt *et al.* (2003) examined fertilizer adoption in Ethiopia, revealed that market access and credits are shown to be major supply-side constraints, suggesting that households generally do not have enough cash to buy fertilizer. The results underline the importance of increasing the availability of credit and reducing the procurement, marketing and distribution costs of fertilizer.

From the review above, it can be concluded that different studies identified different sets of factors that influence adoption of innovations. The variations are due to diverse socio-economic, geographical and environmental circumstances under which different farming communities operate, and the type of technology studied.

2.7 Adoption Theories

Due to the complex of the human behaviour various theories and models have been developed in an attempt to understand and predict human behaviors (DÜvel, 1991). Some of these theories and models include the Traditional Approach, The 5-Stage or “Classical” adoption Process, the Innovation Decision making process and , The Theory of Reasoned Action.

2.7.1 Traditional approach

In a critical analysis of adoption research development, Albrecht (1964) as quoted by DÜvel (1991) identified five distinguishable approaches. These are the teaching method approach, socio-cultural approach, atomistic communication approach, socio-structural communication approach and situational-functional approach.

In all approaches, except the last, generalizations are made regarding the influence of certain categories of variable, but these could not be upheld. The distinct contribution of the situational-functional approach lies in the fact that behavior change is not regarded as the cause of a single factor like methodology of teaching, cultural ties or communication, but rather the function of an interplay of a number of dynamic inter-dependent factors making up the situation (DÜvel, 1991).

2.7.2 The 5-Stage or “Classical” adoption process

Wilkening (1953) and Bohlen (1957) as quoted by Semgalawe (1998), maintain that, consciously or unconsciously, every person goes through certain mental steps during the learning process. Based on this and other research findings the North Central Rural

Committee (1961) developed a model consisting of five stages that an individual passes through before complete adoption of an innovation (DÜvel, 1991).

These are:

1. Awareness: The individual gets to know about the existence of the innovation but has little or no information about it.
2. Interest: The individual becomes interested in the idea and seeks more information about it.
3. Evaluation: The individual mentally applies the innovation to his present and anticipated future situation, and then decides whether or not to try it.
4. Trial: The individual uses the innovation on a small scale in order to determine its utility in his own situation. He may seek specific information about the method of using the innovation at the trial stage.
5. Adoption: At this stage the individual decides to continue the full use of the innovation.

However, the classical adoption process does not necessarily begin with an awareness of an innovation, that it does not for non – rational processes, that the evaluation can take place at different stages and that it does not necessarily end with adoption as the adoption process implies.

2.7.3 The theory of reasoned action

The theory is based on the assumption that human beings are usually quite rational and make systematic use of the information available to them (Ajzen and Fishbein, 1980). The theory argues that people consider the implications of their actions before they decide to engage or not to engage in a given behaviour (Ajzen and Fishbein, 1980).

Beliefs are the fundamental building blocks of the authors' conceptual model. That is the totality of a persons belief serves as the informational base that ultimately determines his attitude, intentions and behaviors (Fishbein and Ajzen, 1975). Generally a person forms

beliefs about an object by associating it with various characteristics, qualities and attributes and automatically and simultaneously acquires an attitude towards that object. (Op.cit). This means a person who believes that performing a given behavior will lead to mostly positive outcome will hold a favorable attitude toward performing the behaviour, while a person who believes that performing the behaviour will lead to mostly negative outcomes will hold an unfavorable attitude toward performing the behavior (Ajzen and Fishbein, 1980). Knowledge of a person's belief and attitude therefore, permit prediction of one or more specific behaviors (Fishbein and Ajzen, 1975).

2.7.4 The Innovation – decision process model

In response to earlier models and the criticism leveled against them, Rodgers (1983) developed the innovation-decision process as the process through which an individual (or other decision making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision.

He proposed five stages that an individual or other decision-making unit passes through in the process of innovation adoption:

1. **Knowledge:** Occurs when an individual (or other decision-making unit) is exposed to the innovations existence and gains some understanding of how it functions.
2. **Persuasion:** Occurs when an individual (or other decision-making unit) forms a favorable or unfavorable attitude toward the innovation
3. **Decision:** Occurs when an individual (or other decision-making unit) engages in activities that lead to a choice to adopt or reject the innovation

4. Implementation: Occurs when an individual (or other decision-making unit) puts an innovation into use.
5. Confirmation: Occurs when an individual (or other decision making unit) seeks reinforcement of an innovation decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation.

In his model, Rodgers (1983) recognizes the importance of felt needs or problems in adoption behaviour but they fall under “prior conditions” rather than being critical or key dimension in behaviour change (DÜvel, 1991). However, Rodgers is not clear on whether needs or awareness of innovation initiate the process or whether it is the knowledge of an innovation or new idea. He referred to this as a “chicken or egg” problem.

As far as the stages are concerned, Van den Ban and Hawkins (1988) point out that the innovation - decision process does not always follow this sequence in practice and also that there is insufficient evidence to prove these stages of innovation decision exist.

Rodgers (1983) solved the problem of the sequence of the phases, by reducing them to only two before decision making. However this does not offer much help as a guide to bring about change and is a further model that only explains how change takes place (DÜvel, 1991).

2.8 Methodologies Employed in Adoption Studies

Both probability and purposive sampling are used in adoption studies. Large samples are normally used especially when rigorous econometric analyses are involved. Formerly multivariate linear regression analysis was the common analytical tool for determinant of

adoption but the linear probability model (LPM) and cumulative distribution function (CDF) are becoming popular (Bisanda *et al.*, 1998; Kaliba and Marsh, 1999; Feder, *et al.*, 1985; Ntege-Naneenya *et al.*, 1997). CDF models take into consideration of non-linear characteristic, which is typical in adoption data. Although LPM is the simplest, it has limitations. Estimated probabilities for LPM may fall outside the 0-1 bounds. It also suffers non-normality and heteroscedasticity problems.(Gujarati,1995). CDFs include Probit and Logit probability models as suggested by Gujarati (1995).

Probit and Logit models measure the relationship between the strength of stimulus and the proportion of cases exhibiting a certain response to the stimulus. These models are appropriate tools in situation where there is a dichotomous output that is thought to be influenced by levels of some independent variable(s). Moreover, they are useful in estimating the strength of stimulus required to induce a certain proportion of responses, such as the probability of adoption resulting from farming experience. The models are quiet appropriate analysing cross sectional data with binary dependent variable. In some cases they have been used to analyze time- series-cross-section (Nathaniel and Jonathan, 1997).

The difference between the two models is that Logistic curve has flatter tails than probit curve. Probit curve approach the axes quickly than Logistic curve. A Logistic estimate of a parameter multiplied by 0.625 gives a fairly good estimate of probit mode (Ibid.). Choice between the two models is that of mathematical convenience and ready availability of computer soft ware.

Logit model has been widely used in wheat and maize studies. For instance, in southern highlands of Tanzania, a logistic regression model was used to analyse factors affecting adoption of improved wheat (Mwanga *et al.*, 1999). They found that household size; farm size and extension contact had significant influence on adoption of improved wheat varieties. The same model was used in maize study in Uganda and wheat study in Ethiopia by Ntege-Nanyeenya *et al.* (1997) and Regassa *et al.* (1998) respectively. Using the model, (Ibid.) found that education; farmers' group and land tenure had statistically significant effect on adoption of improved maize. The logistic model is also applicable in analysis of land conservation technologies. For example logit regression model was used to analyse factors influencing adoption of soil conservation in Tanzania (Kalineza *et al.*, 1999; Senkondo *et al.*, 1998; and Lazaro *et al.*, 1999). It was also used in Tennessee by Roberts *et al.* (2002) to determine factors affecting the location of precision farming technology. Also Heissey *et al.* (1993) used the logit model to determine adoption of new wheat varieties in Pakistan. Nzomoi *et al.* (2007) applied the same model to assess determinants of technology adoption in the production of horticultural export produce in Kenya.

This study utilized the logit model because the dependent variable is dichotomous and the model is computationally simpler. The probit model was not used because of the non linear nature of the variables used in this study since it assumes cumulative normal distribution. Kipsat (2002) also rejects the use of the probit model on the grounds that it leads to inefficient estimators and that the estimated probabilities are not constrained to lie between the (0, 1) range demanded by probability theory.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Overview

This chapter discusses research design and related matters of the study area. The chapter has six sections namely description of study area, research design, sample size and sampling procedures, data collection and limitations and specification of the logit model.

3.2 Description of the Study Area

3.2.1 Location

The study was conducted in Babati and Hai district. Babati district is one of the five districts in Manyara region and Hai district is one of the six (6) districts in Kilimanjaro region. These districts are located in the Northern zone of Tanzania.

3.2.2 Climate and topography

Babati and Hai districts have a bimodal type of rainfall, with an annual range of 500mm-1200mm and 350-2000mm respectively. The altitude ranges from 950m to 2,450m above sea level. The soils are of volcanic origin and range from sand loam to clay alluvial soils. The long rains are obtained in March to June, whereas the short rains season normally lasts from end of October to December.

3.2.3 Population

According to the 2002 census the Babati and Hai districts had a population of 303 013 and 259 958 respectively (URT, 2003).

3.2.4 Land use

In Babati District, most of the land is used for crop production and livestock keeping (180 000 and 212 000 ha respectively). Other land uses are park, game reserves and lakes (1142 500 ha), forests (31 775 ha) and other uses (40 525 ha). The main food crops grown are maize, paddy, sorghum and common beans. Cash crops are Pigeon peas, coffee and sunflower. The major types of livestock kept are cattle, goat, sheep, pigs, donkeys and poultry (BDC 2007). Hai district occupies an area of 216 900 ha whereby 100 000 ha is potential agricultural land of which 72 400 ha is under cultivation. The main food crops grown are maize, beans and banana. The major types of livestock kept are dairy cattle, goats, sheeps, pigs and chicken (HDC, 2006).

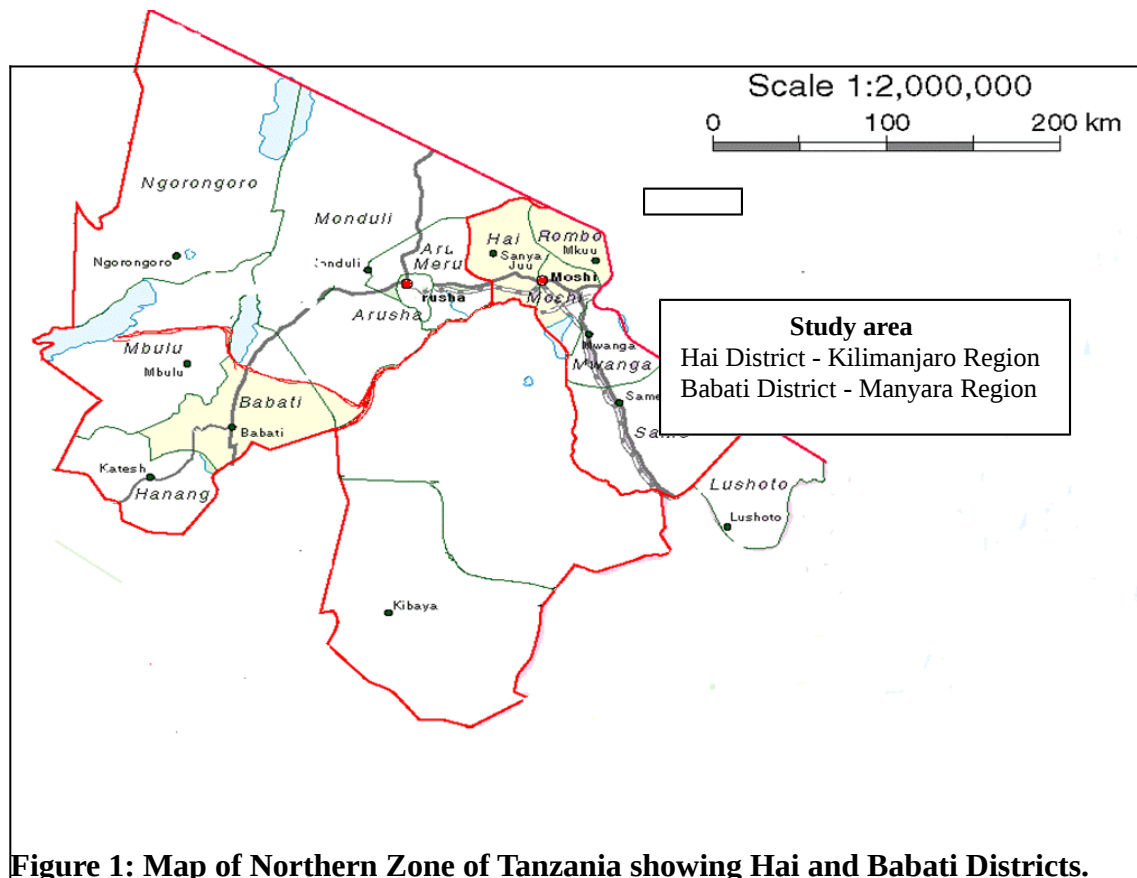


Figure 1: Map of Northern Zone of Tanzania showing Hai and Babati Districts.

3.3 Research Design

Non-experimental design was employed whereby cross sectional research design was used. The design allows for descriptive analysis as well as for exploring and verification of relationships between variables. The target population of the study was maize farmers.

3.4 Sample Size and Sampling Procedures

In consultation with the farming systems/socio-economics department of SARI, and DALDOs, multistage purposive sampling techniques were employed to select districts, wards and villages. Two districts were selected purposively one from Kilimanjaro Region (Hai district) and the other one from Manyara region (Babati district). At the ward level, two wards (Mamire and Bonga in Babati; Masama South and Machame North in Hai District) were also purposively selected. The criterion for selection was based on the fact that these districts, wards and villages were in the pilot area for Quality Protein Maize Development (QPMD) project for the Horn and East Africa 2003. Therefore various promotional and dissemination activities like field demonstrations, field days, various recipes production and seeds production have been conducted in these areas since the inception of the project. One village was selected from each ward, making a total of four villages for the study. The villages selected were Endakiso, Bonga (Babati), Mungushi and Nshara (Hai). An entire list of maize farmers' households' heads was prepared during the introductory visit with the help of Village Agricultural Extension officer (VEOs). From this list a total of 30 maize farmers household heads from each village were randomly selected making a total of 120 sampled household heads that were interviewed (Table 1).

Table 1: Distribution of the sample

District	Ward	Villages	Sampled household head
Babati	Mamire	Endakiso	30
	Bonga	Bonga	30
Hai	Masama South	Mungushi	30
	Machame North	Nshara	30
Total			120

3.5 Data Collection

Both secondary and primary data were collected for the study. Secondary data sources included published and unpublished information, research reports, scientific papers, journals, books, and various reports from Sokoine National Agricultural Library (SNAL), District Agricultural and Livestock Development Offices (DALDOs) and different websites on the internet.

Primary data were collected from household head using semi-structured questionnaire. The questionnaire was pre-tested in a pilot survey in the district in order to determine their relevance and the quality. After the pre testing, the questionnaires were revised to obtain the final version. Modified version of the questionnaire was used to solicit information from farmers.

The enumerators who administered the questionnaires underwent a preparatory training before embarking on the field work. This was necessary to avoid unnecessary mistakes in data collection. Interviews were done at farmers homestead and where necessary on farmers field.

3.6 Data Analysis

The data collected was summarized, coded, and analyzed by using Statistical Packages for Social Science (SPSS) software, version 12.0. Both Descriptive statistics including mainly frequency distribution and comparison of means were carried out. Data coded in SPSS were transferred to STATA software version 8 for Logistic regression analysis so as to determine factors affecting adoption of QPM technology. Regression analysis was carried out to establish effect-cause relationship. In this study, Cumulative Distribution Functions (CDF) specifically logit model was used to determine the influence of a number of pre-indicated variables on adoption of QPM technology. Choice of independent variables was based on literature review, and socio-economic theory governing the adoption of innovation.

3.7 Data Limitation

The following are the problems that were encountered during the data collection exercise.

- i. Poor record keeping among the farmers. Farmers in the surveyed area do not keep records of their last maize production. Apart from recording keeping there was skepticism in provision of information.
- ii. Lack of transparency. The problem was minimized by careful probing the interviewee.
- iii. Some respondents were reluctant in giving information on the questionnaire or escape from interviews

However, in spite of the above limitations, it is expected that the data collected was reliable and adequate to address the objectives set forth in the study.

3.8 Specification and Estimation of the Logit Model

The study employed a logistic regression model to determine factors influencing adoption of QPM technology. The logistic model is a probabilistic model that explains the possibility that one will select to adopt new varieties given a combination of factors (socio-economic variables).

According to Nzomoi *et al.* (2007), the estimated logistic model is given by:

$$\log\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_{13} x_{13} + e \dots \dots \dots (1)$$

3.9 Factors Influencing Adoption of QPM Technology

The factors hypothesized to influence the adoption of QPM technology are listed in Table 4. A farmer's decision either to adopt or reject a new technology is influenced by the combined effect of a number of factors related to farmers' objectives and constraints (CIMMYT, 1993).

In this study, three aspects were considered in the analysis of factors associated with the adoption of QPM:

1. Farmers' demographic characteristics (e.g., age, gender, education level household size);
2. Farmers' socio-economic factors (e.g., farm size, livestock ownership); and
3. Institutional support systems available to farmers (including; credit, extension, Research and seed source).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the results and discussion for the data obtained from the study. It includes overall demographic and socio-economic characteristics of the sample households (adopters and non adopters). The chapter also presents the rates of adoption of QPM and factors influencing its adoption in the study area.

4.1.1 Demographic Characteristics of Adopters and nonadopters

Adopters in this study are any sampled household head who had ever planted QPM while nonadopters have never planted QPM. The study shows that from the randomly selected (120) household heads, thirty (30) were adopters while the remained ninety (90) were non adopters.

Characteristics of households are known to be associated with adoption. Such characteristics include age, education level, family size, and gender. Household head characteristics of sample household, QPM adopters and nonadopters are shown in Table 2. The mean age of household head of adopters was 48 and 45years for non adopters. The age was significantly different at ($p < 0.05$). Household heads for adopters were older compared with household heads for nonadopters. No significant difference was found in the number of years in schooling. The mean number of years was 7.3 and 6.36 for adopters and non adopters respectively. Farm size and farming experience between adopters and non adopters of QPM technology had no significant differences. The average number of years of farming experience of both adopters and non adopters of QPM technology was 22 years.

The study showed that there was significant difference in household size ($P < 0.001$) between adopters and non adopters. In the study area, the average households' size for adopters was comparatively higher than the nonadopters. The mean household size of the adopters and nonadopters was 6.6 and 5.9 persons respectively. This suggests that adoption of QPM technology was associated with large household sizes. This is because for small holder farmers, household labour is the most dependable source of labour. The household characteristics of adopters and non adopters are presented in Table2.

Table 2: Household characteristics of the sample

Characteristics of household head	Adopters (n= 30)		Non-adopters (n=90)	
	Mean	SD	Mean	SD
Age (years)	48	13.8	45.1	11.9
Household size	6.6	2.6	5.9	2.7
Farming experience (years)	22.2	12.9	22.3	22.5
No. of years in schooling	7.1	2.6	6.4	2.2
Farm size (acres)	4.3	3.1	3.5	2.8

4.1.2 Distribution of household head by gender

The results show that, there was significant difference in distribution of household heads by gender with both non adopters and adopters having large proportion (74.4% and 60%) of male headed households respectively (Table 3). This indicates that, the majority of the household are male headed and thus may influence decision in adoption of QPM in the study area. The household heads gender become critically important in circumstances where the farming community allocates responsibilities based on gender differences.

Table 3: Household heads distribution by gender

Gender	Adopters		Non adopters	
	Frequency	%	Frequency	%
Male	18	60.0	67	74.4
Female	12	40.0	23	25.6
Total	30	100.0	90	100.0

4.2 Socio-economic Characteristics of Household

Socio economic characteristics (farm size, off farm activities and livestock owned) are among the variables which affect the uptake of technology.

4.2.1 Farm size

The mean farm size for the sampled households was 1.0ha of which 51% was under maize in 2007/08 cropping season. Mode of land acquisition in the area were; inheritance, borrowing, purchasing and hiring. Adopters possessed more land than non adopters in terms of total farm size although the difference was not significant. The average area of land allocated by adopters and non adopters for maize production was 0.6 and 0.5ha respectively (Table 4). Indicating that, most of the households in the surveyed area are small holder farmers because of the problem of land scarcity in Babati and Hai districts. Mean farm size for adopters and nonadopters were 1 and 0.7 ha respectively (Table 4).

Table 4: Farm size (ha) of adopters and nonadopters

Farm characteristics	Adopters		Non adopters	
	Mean	SD	Mean	SD
Land owned	1.0	0.8	0.9	0.7
Area under maize	0.6	0.4	0.5	0.4

The average area of land allocated by adopters and nonadopters for maize production was 0.6 and 0.5 ha respectively.

4.2.2 Crops grown

The most important crops grown in the study area are maize, beans, pigeon peas and sunflower (Table5). Pigeon peas and Sunflower are the major cash crops grown in Babati while maize, beans and coffee are the major cash crops in Hai.

Table 5: Important cash crops grown in Babati district

Crops	Babati		Hai	
	Frequency	Percent	Frequency	Percent
Sunflower	22	36.7	-	-
Pigeon peas	38	63.3	-	-
Maize	-	-	16	26.7
Beans	-	-	16	26.7
Coffee	-	-	24	40
Vegetables	-	-	4	6.7
Total	60	100.0	60	100.0

Maize was reported to be the most important food crops (100% and 98%) for Babati and Hai respectively (Table6).

Table 6: Important food crops grown

	Babati(n=60)		Hai(n=60)	
	Frequency	Percent	Frequency	Percent
Maize	60	100.0	59	98.3
Banana	-	0.0	1	1.7

4.2.3 Off farm activities

Table 7 shows that 36.7% and 56.7% of the sampled adopters and non adopters involved in off farm activities respectively. There was significant different ($p < 0.01$) in number of adopters and non adopters involved in of farm activities. The results showed that adopters are less involved in off-farm activities than non adopters of QPM technology. Casual

labour was the type of work mostly reported to be done by adopters (55.6%) and there was significant difference ($P < 0.05$) between adopters and non adopters. This indicates that, the available labour force is either used in family own farm and or hired for to obtain cash. Off farm activities are sources of additional income which may encourage or discourage investment in new technologies. In this study the main off farm activities were casual labour, salary employment, carpentry and petty business.

Table 7: Off-farm activities

Characteristics	Adopters		Non adopters		χ^2 statistic
	Respondents	Percent	Respondent	Percent	
Involvement in off farm					
Yes	19	36.7	51	56.7	3.33*
No	11	63.3	39	43.3	
Total	30	100.0	90	100.0	
Type of work					
Casual labour	10	55.6	15	30.6	7.95**
Salaried employment	2	5.6	13	24.5	
Carpentry	2	5.6	9	18.4	
Petty business	6	33.2	13	26.5	
Total	20	100.0	50	100.0	

*=Significant at 10% level, **=Significant at 5% level, NS = not significant.

4.2.4 Livestock owned

The study shows that, the average number of livestock kept per household for adopters was 3 cows, 2 bull, 5 goats, 2 sheep, 3 pigs and 13chicken and 2 cows, 2 bulls, 5 goats, 3 sheep, 2 pigs and 9 chickens for non adopters (Table 8).This results indicate that adopters have more livestock number than non adopters. This is probably that, farmers (Adopters) can occasionally sell some of their live stocks and the money obtained from sales can be used to buy seeds and other inputs for production of new crop such as QPM technology. A higher number of livestock also serves as a buffer against risks and uncertainties associated with crop production such as crop failure. This implies that, as farmers diversify their economy including livestock keeping it becomes easy for them to try new technology such as QPM and adopt it. The number of livestock units owned by a farmer was hypothesized to affect the adoption of improved technologies, since the number of livestock kept may represent a ready source of cash for purchasing farm inputs

Table 8: Number and type of livestock owned

Livestock type	Adopters		Non adopters	
	Mean	SD	Mean	SD
Cows	2.96	2.36	2.37	1.34
Bulls	2.37	1.33	2.11	1.04
Goats	5.10	4.02	4.71	6.31
Sheep	2.30	1.02	2.51	2.55
Pigs	2.50	2.50	2.04	0.67
Chicken	13.37	10.56	8.89	10.57

4.3 Institutional Characteristics

According to Lin and Nugent (1999) an institution is a set of behavioral rules that govern and shape the interactions of human beings, in part by helping them to form expectations of what other people will do. Such institutions supporting systems include extension services, research, seed/input provisional services (inputs stockists) and credit facilities. Institutions are considered as mechanisms used to structure human interactions in the face of uncertainty, and as they are formed to reduce uncertainty and risk in human exchange. Institutions help human beings to form expectations of what other people will do (Kirsten *et al.*, 2009).

4.3.1 Extension services

In the study area, about 54% and 27% of the QPM adopters and nonadopters had access to agricultural extension services respectively (Table 9). This indicates that most of the sampled household heads did not receive extension visits. This is probably due to lack of appropriate means of transport and wider coverage per extension worker as it has been reported by the respondents that there was only one extension worker per division in the surveyed area. The study by Baidu –Forson (1999) observed that adoption was higher for farmers having contact with extension agents working on agroforestry technologies than farmers who have never experience any extension contacts. Extension is known to catalyze awareness, organization, and information exchange and technology adoption among farmers. Extension service is crucial in uptake and adoption of improved technologies. The number of extension workers per unit of population influences extension delivery.

4.3.2 Access to credit

About 26.7% of adopters and 54.4% non adopters reported to access credit facilities in their area (Table 9). In the study area there was none formal credit facility for maize production. This demonstrates that credit facilities that exist provide credits for other activities. The major problems that were reported about credit facilities that were available are, long processes in obtaining credits, short repayment period and lack of information. Credit sources in the study area are SACCOS, VICOBA, BRAC Cooperative union and World Vision.

Table 9: Membership to farmers' organization, access to extension services, credit, on farm demonstrations and farmers field days

Characteristics	Adopters	Non adopters
	(n=30) %	(n=90) %
Membership in farmers organization/group		
Yes	70.0	33.3
No	30.0	66.7
Farmers access to extension		
Yes	54.0	27
No	46.0	73
Participation in on farm demonstration trials		
Yes	90.0	33.3
No	10.0	66.7
Attendance to farmers field days		
Yes	63.7	3.3
No	33.3	96.7
Farmers access to credit		
Yes	26.7	54.4
No	73.3	43.3

4.3.3 Membership to farmers' organization /group

In the study area, these groups are organized by researchers and other development agencies in various agricultural aspects. Examples of these are Kware Lishe group, coffee cooperative society and Mkombozi of Hai and organic farming, Dairy goat groups and sunflower production group of Babati. About 70% of adopters and 33% of nonadopters had membership in farmer organizations/groups (Table 9). Being a member of farmers group put a farmer in a privileged position in relation to other farmers. Group members have better access to technical information and receive preferential treatment from extension workers and other development agents

4.4 Adoption of QPM Technology

4.4.1 Awareness and spread of QPM

From the results of the study, there was high degree of awareness of the QPM technology among the respondents. The level of awareness of QPM technology was 70.8% (Table 10). The results showed that Hai District was more aware of the QPM technology than Babati District. The slightly higher percentage of awareness in Hai District could be due to the fact that most of the QPM technology promotion and dissemination activities conducted by SARI such as, QPM Field demonstrations at Farmers' fields and at NANE NANE Agricultural Show grounds which is located nearer to Hai compare to Babati district.

It is not possible for farmers to adopt a technology they do not know (Oluko *et al.*, 2000). Which means, before any accumulation of knowledge and experiences start, farmers must be aware of a new technology in their environment. Without awareness, the process of accumulation of information by target farmers is not possible Awareness is therefore the initial stage in any adoption process. Farmers had to know about new innovation before

adopting it (ibid.).

Table 10: Awareness of QPM

Awareness of QPM	Adopters (n=30)		Nonadopters (n=90)		Total
	Number of respondents		Number of respondents		
	(%)		(%)		
	Babati	Hai	Babati	Hai	
Yes	14 (46.6)	16 (53.4)	24 (52.1)	31 (70.4)	85 (70.1)
No	0	0	22 (47.9)	13 (29.6)	35 (29.9)
Total	14	16	46.	44	120

4.4.2 Source of QPM technology information

The major information sources about QPM as reported by respondents were researchers (37.7%) and farmers' field day (28.2%) respectively. These were organized by SARI for the purpose of promoting and disseminating QPM technology in these areas. Table 11 shows that 70.1% of the respondents had information about QPM. However, only 35.3% of these have adopted the technology while 64.7% have not.

Table 11 : Source of QPM technology information

Source of QPM information	Adopters (n=30)		Nonadopters (n=55)		Total
	Number of respondents		Number of respondents		
Researchers	10 (11.8)		22 (25.9)		32 (37.7)
Farmers field days	13 (15.3)		11 (12.9)		24 (28.2)
Other farmer	4 (4.7)		14 (16.5)		18 (20.2)
Extension agents	3 (3.5)		3 (3.5)		6 (7.0)
Village leaders	-		2 (2.4)		2 (2.4)
Farmers group	-		3 (3.5)		3 (3.5)
Total	30 (35.3)		55 (64.7)		85 (100)

Note: The number of non adopters who are not aware of QPM =35 Values in brackets are %

4.4.3 Rate of adoption

The rate of adoption is measured in terms of the proportion of the sample farmers growing QPM. In the surveyed area QPM was introduced since 2001. About 25% of the surveyed farmers cultivated QPM in 2007/08 cropping season (Table 12). The analysis also showed

that all adopters cultivated Lishe K1 QPM variety. There were no significant variations in adoption rates across the surveyed districts. Hai district had slightly higher adoption rate (26.6%) compared to Babati district (23.3%). This could be attributed probably by the reason mentioned earlier that, most of the QPM technology dissemination activities have been conducted in Hai district.

Table 12: Adoption rate of QPM technology

	Adopters (n=30)		Non-adopters (n=90)	
	Number of respondents	Percent	Number of respondents	Percent
Babati	14	23.3	46	76.6
Hai	16	26.6	44	73.3
Overall	30	25.0	90	75.0

4.4.4 Initial Source of QPM seeds

The initial sources of QPM seeds as indicated by adopters were researchers (29.2%), farmers' field day (15%), farmers group (3.3%) and from village leaders (1.6%) Other source was from other farmers (23.4%) and MVIMAHA for Hai districts. Others were seed multiplication group (6.7%), and from the stockist (1.7%) in Babati district (Table13).

Table 13: Initial sources of QPM seeds for adopters (n=30)

Source	Districts		Total
	Babati (n=14)	Hai (n=16)	
	Number of respondents	Number of respondents	
Researchers	7 (23.3)	5 (16.7)	12 (40.0)
Extension agent	4 (13.3)	1(3.3)	5 (16.6)
MVIMAHA	-	8(26.7)	8 (26.7)
Farmers seed multiplication group	-	2 (6.7)	2 (6.7)
Other farmer	2 (6.7)	-	2 (6.7)
Stockist	1(3.3)	-	1 (3.3)
Total	14 (46.6)	16 (53.4)	30 (100)

Note: values in brackets are %

4.4.5 Adopters of QPM in 2007/8 cropping season

In 2007/08 very few sampled household heads (adopters) (2% and 5%) from Babati and Hai respectively planted QPM. Table 14.

Table 14: Adopters in Babati and Hai districts in 2007/08 Cropping season

District	Cultivated QPM	Number of	Percent
		respondents	
Babati	Yes	2	3.3
	No	58	96.7
	Total	60	100.0
Hai	Yes	5	8.3
	No	55	91.7
	Total	60	100.0

4.4.6 Source of QPM seed for 2007/08 cropping season

Sources of QPM seed by adopters for the cropping season were from other farmer and stockist for Babati and from MUVIMAHA for Hai Table 15.

Table 15: Sources of QPM seed for 2007/08 cropping season

Source	Babati(n=2)		Hai(n=4)	
	Number of respondents	Percent	Number of respondents	Percent
From other farmer	1	1.7	-	0.0
Stockist	1	1.7	-	0.0
MUVIMAHA	-	0.0	5	6.7
Total	2	3.4	5	6.7

4.4.7 Reasons for not adopting

Table 16 summarizes the major reason for not adopting QPM technology as given by the sampled nonadopters. The major reason for low adoption as mentioned by respondents included non availability of QPM seeds as indicated by 45% and 25.7% of the respondents were not aware.

Table 16: Major reasons for not adopting (n=90)

Reason	Number of respondents	Percent
No reliable QPM seed source	41	45.6
Not aware	23	25.7
Average yield potential	8	8.8
Lack of QPM nutritional benefits knowledge	11	12.2
QPM seeds are expensive	6	6.6
Shortage of land	1	1.1
Total	90	100.0

4.4.8 Adoption intensity/extent of QPM technology adoption

The adoption intensity measures the depth or extent of adoption expressed in terms of the proportion of the total cultivated area or maize growing area allocated to QPM. The average land allocated by adopters for maize was 2.20acres and 1.8acres for Babati and Hai districts respectively. The average area cultivated QPM was 15% and 34% of the total maize cultivated land for Babati and Hai district respectively. Other maize varieties cultivated by sampled adopters are *Kilima* and *Staha* (OPVs) and H 511 SC 627 DK 8071 and PAN 67 (Hybrids).

The results shows that in 2007/08 cropping season, the mean QPM cultivated land decreased from 0.43 acre in 2004/05 to 0.20 acre in 2007/08 and from 0.62 acre to 0.55 acre cropping seasons for Babati and Hai respectively which was about 53.5% and 11.3% decrease of QPM cultivated area respectively (Table 17).The main reasons given for these trends were; no reliable source of QPM seeds and stockists and average yield potential of QPM compared to other maize varieties grown in the study among others. Farmers' future plans to increase the area under QPM varieties, was reported by 30% of the sample households. The reasons given were; QPM matures early, it tastes well and if QPM seed made available.

Table 17: Area under QPM

Cropping season	Average area (acre) N=120			
	2004/05	2005/06	2006/07	2007/08
Babati	0.43	0.40	0.28	0.20
Hai	0.62	0.63	0.63	0.55

4.4.9 Uses of QPM in the study area

Uses of QPM as indicated by adopters were for ugali, makande, porridge, roasting and boiled just like normal maize. The study showed that there are many uses of QPM in Hai compared to Babati. Also higher percent (73.3%) of respondents who have never use QPM in Babati compared to Hai (50%) Table 18.

Table 18: Uses of QPM

Uses	Babati(N=60)		Hai(N=60)	
	Number of respondents	Percent	Number of respondents	Percent
Ugali	8	13.3	14	23.3
Porridge	7	11.7	5	8.3
Roasting	1	1.7	2	3.3
Makande	-	-	3	5
Boiled	-	-	6	10

N/A	44	73.3	30	50
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4.4.10 Consumption of QPM

Tale 19 summarizes the consumption of QPM in the study area. The study showed that 3.3% and 6.7% of the adopters from Babati and Hai respectively very often consumed QPM, 20% from Babati and Hai occasionally consumed QPM. The remaining 46% of Babati and 44% of Hai were non adopters and therefore never consumed.

Table 19: Consumption of QPM

Consumption	Babati		Hai	
	Number of respondents	Percent	Number of respondents	Percent
Very often	2	3.3	4	6.7
Occasion	12	20	12	20
Never consumed	46	70.7	44	73.3
Total	60	100.0	60	100.0

4.4.11 QPM Marketing

The study showed that about 43.3% and 9.2 of the respondents sold normal maize and QPM respectively during 2006/07 cropping season Table 20.

Table 20: Maize Marketing

Sold maize	Normal maize N=120		QPM N=120	
	Number of respondents	Percent	Number of respondents	Percent
Yes	52	43.3	11	9.2
No	68	56.7	19	90.8
Total	120	100.0	90	120.0

The study also showed that 91% of the QPM were sold to traders while the 9% was sold to neighbors Table 21.

Table 21: Buyers of QPM

Buyers	Number of respondents	Percent
Traders	10	91.0
Neighbours	1	9.0
Total	11	100.0

Price perception by farmers for QPM was 45.4% and 54.6% fair and poor respectively Table 22, which indicates that farmers are not happy with the price of QPM maize. Farmers reported that there is no special market for QPM thus QPM and normal maize is sold to similar market and fetch same price. This might be one of the reasons for the observed low adoption rate of QPM technology.

Table 22: QPM price perception

Perception	Number of respondents	Percent
Good	0	0.0
Fair	5	45.0
Poor	6	55.0
Total	11	100.0

4.4.12 Farmers' opinions on how to improve adoption

Farmers suggested several approaches to enhance the use and adoption of QPM technology by small-scale farmers in Tanzania. It was recognized that QPM seeds is not available at the village level; also farmers need QPM market since there is no different in prices with normal maize. Farmers suggested for more training seminars and sensitization activities on QPM production utilization and its nutritional benefits as are not clearly known to many farmers. The respondents proposed the improvement of QPM production potential and one of the adopters suggested the use of fertilizers to increase QPM yield (Table 23).

Table 23: Farmers Suggestions for Enhancing the Uptake of QPM Technology

Opinion	Number of respondents	Percent (%)
QPM seed made available at the village level on credit	37	30.8
Need special market for QPM	15	12.5
Need sensitization about QPM	24	20.0
Conduct seminars and training on QPM in the village	30	25.0
Researchers to Improve QPM production potential	10	8.3
Increase number of field demonstration	3	2.5
Farmers to use fertilizer	1	8.0
Total	120	100.0

Adoption of QPM technology was analysed using logit analysis model. The model predicts the probability of these factors influencing farmers QPM technology adoption.

4.5 Logistic model estimates

Estimation of the adoption model included different explanatory variables (regressors) presented in Table 24. The Maximum Likelihood Method was used for estimating the variable coefficients and marginal effects (elasticities) of regressors on the probability of adopting QPM technology. The variables included in the model were age of the household head (AGEHH), gender of the household head (GENHH), education level of the household head in years (FEDUYRS), household size (HHDSIZE), number of household members working on farm (HHWONF), farm size (FAR.SIZE), whether or not a household head attended agricultural training (FTRAI), whether or not a household keeps livestock (LIOHH), whether or not a household head attended farmers field day (FAFFD), whether or not credit services are available in the study area (CREFAV), number of extension visits (EXTCO) whether or not a household head have participated in QPM on farm trials (DEMTRIA), and household head perception on QPM marketing (QPMKT). Other variables were dropped by the analytical software (STATA) to avoid multicollinearity such as farmers' experience, availability of credit services and access to extension services. All

variables included in the model possess the hypothesized direction of influence on the probability for farm household to adopt QPM technology.

Results from Table 24 indicate that number of years in schooling (FEDUYRS) of the household was significant at ($p < 0.1$) and positively influences the adoption of QPM technology. This confirms with the expected sign. Furthermore, it suggests that a unit increase in number of years in schooling increases the probability (likelihood) for a household to adopt the technology by 45% (marginal effect). Nkonya *et al.* (1997) have found a positive relation between education level of the farmers and the adoption probability of improved maize seed in northern Tanzania. Ersado *et al.*, (2004) in their study on productivity and land enhancing technologies in northern Ethiopia have found that more educated household's heads are well informed and receptive, which translates into a higher likelihood of engaging in new technologies.

Table 24: Logit model results for factors influencing the adoption of QPM technology

Explanatory variable	Coefficient	Marginal effects (dy/dx)	Std error	Probability
AGEHH	0.03	0.00	0.41	0.48
GENHH	0.88	0.36	1.28	0.49
FEDUYRS	0.45	0.02	0.22	0.06*
HHDSIZE	0.07	0.00	0.18	0.69
HHWONF	-0.76	-0.00	0.39	0.85
FARSize	0.12	0.00	0.16	0.46
FTRAI	-1.47	0.06	1.25	0.24
FAFFD	2.17	0.11	1.11	0.04**
LIOHH	3.26	0.06	1.85	0.08*
DEMTRIA	4.75	0.54	1.52	0.00***
EXTCO	-0.03	-0.00	0.35	0.93
QPMRKT	-1.13	-0.05	0.34	0.00***
ACCRED	-3.82	-0.16	1.37	0.03**
Constant	-8.79		4.19	0.04
Number of observation	= 120	Pseudo R ²	=	0.69
LR chi ²	= 93.39	Log Likelihood	=	-20.78

Prob. > χ^2	=	0.00
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Note: * Indicates significance at 10% level, ** Significance at 5% level and ***

Significance at 1%

Number of livestock owned by the household (LIOHH) was positive and statistically significant at ($p < 0.1$). This entails that a unit increase in number of livestock increase the probability of the household to adopt the QPM technology by 6% (marginal effect). Pitt and Sumodiningrat (1991) note that the positive relationship that they identify between adoption of high-yielding varieties and the value of livestock holdings may be related to the effect of the diversity of income sources on a household's willingness to take on a riskier investment.

Participation of farmers on on-farm demonstration trials (DEMTRIA) was statistically significant ($p < 0.01$) and positively associated to the rate of adoption of QPM technology (Table 24). The results suggest that participating in on-farm demonstrations increases the probability of adopting the technology by 54% (marginal effect). Zhang *et al.* (2002) examine the adoption of HYV (high yielding variety) seeds in India, suggested that demonstration fields could be used to speed up the adoption of technology

Table 24 shows that attendance to farmers' field days (FAFFD) was statistically significant at $p < 0.05$ level and positively related to the rate of adoption of the technology. This implies that attending farmers' field day increases the farmers' likelihood to adopt the technology by 11% (marginal effect).

Farmers' perception on QPM market (QPMKT) was strongly significant at 0.01 levels but negatively related to rate of adoption of QPM technology. This is contrary to the

hypothesized sign. It is attributed by the unavailability of special QPM market in surveyed area as it was reported by farmers.

Unexpectedly access to credit by household head (ACCRED) in the study area was strongly significant ($p < 0.01$) but negatively related to rate of adoption of QPM technology (Table 25). This was also contrary to the expected sign and economic theory too. As household access credit in the study area the probability to adopt QPM technology decreased by 16% (marginal effect). This means that the accessed credit was not invested on the technology in question resulting into low (25%) rate of adoption. This is probably due to the fact that there is non credit facility for maize production in the study area as reported by the respondents earlier. These results comply with that of Tovignan and Nuppenau (2004) where access to credit was found to be negatively related to organic cotton adoption decision whereby organic farmers had no official credit system reserved for conventional farmers. The findings reject the Null hypotheses that there is no significant factors' affecting adoption of QPM in the study area

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CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

The general objective of this study was to determine the rate of adoption and examine factors that influence farmers' adoption of QPM technology. The Specific objectives were to determine the rate of adoption of QPM technology in the area, to compare socio-economic characteristics of adopters and non adopters of the area and to determine factors affecting adoption of QPM technology.

5.1 Conclusion

The analysis of the rate of adoption of QPM technology has shown that about 70.8% of farmers included in the study were aware of the technology. The rate of adoption of the QPM technology was low (25%). The possible factors attributing to this low rate were: unavailability of QPM seeds, lack of credit facilities for maize/QPM production, information about QPM technology and its production and marketing.

There were no significant variations in number of adopters across the study areas. Relatively large farm size and livestock (chicken) owned were recorded from adopters compared to nonadopters. High proportion of adopters reported to have participated in on-farm trial and attended farmers field days compared to nonadopters. Moreover, high percent of adopters were members of farmers' organizations/groups. On the other hand nonadopters have reported to access credit compared to adopters of the technology.

From the results of the logit model, it can be concluded that number of years spent in schooling by the farmer, farmers' field day attendance, number of livestock owned by the farmers and farmers' participation on demonstration trials are significant factors that influenced positively the probability of farmers to adopt the QPM technology. Moreover, accesses to credit services and perception of farmer on poor QPM marketability particularly in terms of price differentiation and specific market for the product are significant factors that negatively influenced the likelihood of farmers to adopt the technology in the study area.

5.2 Recommendations

The following recommendations are suggested towards increasing adoption rate of QPM technology in Babati and Hai districts and Tanzania in general.

- i) To make the QPM adoption more successful, Ministry of Agriculture efforts to sustain availability of QPM seeds through public, private and CBOs sources to farmers is very important and enough seed must be produced and made available at all levels especially at village levels and at an affordable price so that many farmers can get seed on time.
- ii) Promotion and dissemination activities (such as on farm demonstrations and field days) of QPM by researchers and extensionists to create more awareness to diverse groups including advocacy at all levels for support and partnerships.
- iii) Breeders should continue working for improvement of QPM by converting QPM varieties it into high yielding potential.
- iv) The formal credit system needs to address the credit constraints faced by small-scale farmers and increase awareness about the types of credit available for

agricultural production. In addition, the government through the Ministry of Agriculture Food Security and Cooperatives should encourage farmers to form cooperatives or farmers' groups to reduce transaction costs and improve loan recovery rates.

REFERENCES

- Adesina, A.A., Mbila, D., Nkamleu, G.B. and Endamana, D. (2001). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of Southwest Cameroon. *Agriculture, Ecosystems and Environment* 80 :255 - 265.
- Ajzen, I. and Fishbein, M. (1980). *Understanding Attitudes and Predicting social Behaviour*. Prentice – Hall, Inc., Englewood Cliffs, New Jersey. 763pp.
- Alary, V. (2005). Obstacles to the technology adoption for the small and medium farms in the arid and semi arid areas of Maghreb. [www.femise.org/PDF/a021/fem2105-icarda-gb.pdf]. Site visited on 10.8.2008.
- Anandajayasekeram, P., Martella, D.R. and Rukuni, M. (1996). *A Training Manual on R&D Evaluation and Impact Assessment in Agricultural and Natural Resources Research*, SACCAR. 312pp.
- Baidu –Forson, J. (1999). Factors influencing adoption of land influencing technology in sahel: Lessons from a case study in Niger. *Agricultural Economics* 20(3): 231 - 239.

- Bekele, W. (2003). Theory and empirical application to subsistence farming in the eastern Ethiopian highlands. Swedish University of Agricultural Sciences, Uppsala, Sweden, 210pp.
- Bellon, M. and Risopoulos, J. (2001). Small-scale farmers expand the benefits of improved maize germplasm: A case study from Chiapas, Mexico. *World Development* 29: 799 – 811.
- Bisanda, S., Mwangi, W. Verkuijl, H. Moshi, A.J. and Anadajayasekeram, P. (1997). *Adoption of maize production technologies in Southern Highlands of Tanzania*. Mexico, CIMMYT, United Republic of Tanzania and Southern African Centre for Cooperation in Agricultural Research (SACCAR). 21pp.
- Bressani, R. (1991). Protein quality of high-lysine maize for humans, *Cereal Foods World* 36: 806 - 811.
- CIMMYT (2005). The development and promotion of quality protein maize in Sub-Saharan Africa. [<http://www.net-lanna.info/biotechnology/Abstract/21022412.pdf>]. Site visited on 23/8/2008.
- CIMMYT (2001). The improvement and promotion of quality protein maize in selected developing countries. [<http://scialert.net/pdfs/ajps/2008/375-381.pdf>]. Site visited on 16/4/2009.

- CIMMYT (1993). The adoption of agricultural technologies: A Guide to survey design. Mexico, D.F.: CIMMYT.: CIMMYT Economic Program. 250pp.
- Conley, T. and Udry, C. (2001). Social learning through networks: The adoption of new agricultural technologies in Ghana. *American Journal of Agricultural Economics* 83: 668 – 73.
- Croppenstedt, A., Demeke, M. and Meschi, M. (2003). Technology adoption in the presence of constraints: The case of fertilizer demand in Ethiopia. *Review of Development Economics* 7: 58 – 70.
- Doss, C. (2003). Understanding farm level technology adoption: Lessons learned from CIMMYT's micro surveys in Eastern Africa. CIMMYT Economics Working Paper 03-07. Mexico, 67pp.
- Doss, C., Mwangi, W., Verkuijl, H. and De Groote, H. (2002). Adoption of maize and wheat technologies in East Africa: Synthesis of East African adoption studies. CIMMYT Economics Working Paper 02-04. Mexico, 89pp.
- Doss, C. (2001). Designing agricultural technology for African women farmers: Lessons from 25 years of experience. *World Development* 29(20) 75 – 92.
- Doss, C. R. and Morris, M. L. (2001). "How does gender affect the adoption of agricultural innovation? The case of improved maize technologies in Ghana." *Journal of Agricultural Economics*. 25: 27 - 39.

DÜve, G. H., (1991). Towards a model for the Promotion of Complex Innovations through programmed extension, *South African Journal of Agricultural Extension*, 20:70 – 80.

Ersado, L., Amacher, G. and Alwang, J. (2004). Productivity and land enhancing technologies in northern Ethiopia: Health, public investment and sequential adoption. *In: American Journal of Agricultural Economics*, 86(2): 321-331.

FAOSTAT. (2003). Agricultural database in primary crops yearly production database. [<http://apps.fao.org/page/collections?subset=agriculture>] Site visited on 12/02/2008.

FAO. (2001). Global teach in will help children understand and fight hunger and malnutrition. Rome. [<http://www.fao.org>]. Site visited on 12/02/ 2008.

FAO (1992). Maize in Human Nutrition, FAO, Rome. [<http://www.fao.org/docrep/T0395E/T0395E00.htm>]. Site visited on 12/02/2008.

FAO (1985). Energy and protein requirements: Factors affecting energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation World Health Organization Technical Report Series 724:7.3.3. 67pp.

- Feder, G., Just, R. E. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change* 33: 255 - 298.
- Feder, G. (1980). Farm size, risk aversion and adoption of technology under uncertainty. *Oxford Economic Paper* 32: 263 - 283.
- Feleke, S. and Zegeye, T. (2006). Adoption of improved maize varieties in southern Ethiopia: factors and strategy options. *Journal of Food Policy* 31(5): 442 - 457.
- Fishbein, M. and Ajzen, I. (1975). *Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research*. Addison – Wesley Publishing Company Reading, Massachusetts. Menlo Park, California. London, Don Mills, Ontario Sydney. 459pp.
- Gautam, M. (2000). Agricultural extension: The Kenya experience: An impact evaluation. *Operations Evaluation Studies*, World Bank, Washington DC. 18pp.
- Gujarat, D. (1995). *Basic Econometrics*. McGraw-Hill Inc. New York. 421pp.
- Heissey, P., Tetly, K., Ahmud, Z. and Ahmud, M. (1993). Varietal change in post-green revolution agriculture: Empirical Evidence for Wheat in Pakistan. *Agricultural Economic Journal*. 44(3): 428 - 442.

- Joshi, G. and Bauer, S. (2005). Farmers' choice of the modern rice varieties in the rainfed ecosystem of Nepal. In: *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 107: pp. 129 – 138.
- Kaliba, A. and Marsh, T. L. (1999). House health care in Tanzania, in the intermediate and lowland zones of Tanzania. *Journal of Agricultural and Applied Economics* 32: 35 – 47.
- Kaliba, A., Verkuijl, H., Mwangi, W., Mwilawa, A., Anandajayasekeram, P. and Moshi, A. J. (1998). Adoption of maize production technologies in central Tanzania. Mexico, D.F.: International Maize and Wheat Improvement Center (CIMMYT), the United Republic of Tanzania, and the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR). 34pp.
- Kalineza, H. M., Mdoe, N. S. and Mlozi, M. R. (1999). *Factors Influencing Adoption of Soil Conservation Technologies in Tanzania: A case study in Gairo*. Proceeding of Fouth Annual Research Conference of the Faculty of Agriculture held at the Horticulture Multipurpose Hall, Sokoine University of Agriculture, Morogoro, Tanzania, 17 – 19 April, 1999. 8pp.
- Kipsat, M. J. (2002). Economic analysis of the use of Nnon-conventional fertilizer technologies in Vihiga District of Western Kenya. Thesis for Award PhD Degree at Moi University, Kenya. 157pp.

- Kirsten, J. F., Karaan, A. S. M. and Dorward, A. R. (2009). Introduction to the economics of institutions. In *Institutional Economics Perspectives on African Development*. IFPRI 35-74pp.
- Knight, J., Weir, S. and Woldehanna, T. (2003). The role of education in facilitating risk-taking and innovation in agriculture. *Journal of Development Studies* 39: 1-22.
- Kondouri, P. N. and Tzourvelekas, V. (2006). Technology adoption under production Uncertainty. *Theory and Application to Irrigation Technology. American Journal Economics* 88(3): 657 - 670.
- Kosarek, J., Garcia, P. and Morris, M. (2001). Factors explaining the diffusion of hybrid maize in Latin America and the Caribbean region. *Agricultural Economics* 26(3): 267 – 280.
- Lazaro, E. A. (2000). Adoption surveys Purpose and Procedures. In: *Methodology for Agricultural Research and Impact Assessment*. Proceedings of a Workshop Held Under the Project of Food Security and Household Income for Small holder Farmers in Tanzania: (Edited by Kinabo, L. D. B., Makungu, P. and Mwinjaka, S.), 5-12 December, 2000, Tanesco Training Centre, Morogoro, Tanzania: 27-31 pp.

- Leathers, H. and Smale, M. (2001). A Bayesian approach to explaining sequential adoption of components of a technological package. *American Journal of Agricultural Economics* 73: 734 – 42.
- Leeuwis, C. (2004). Communication for rural innovation. Lowlands of Tanzania. Blackwell Publishing, Oxford. *Tanzania Journal of Agricultural Science*. 1(1): 81-89.
- Lin, J. Y. and Nugent, J. B. (1999). Institutions and economic development. The Economics of Soil Conservation in Crop Residue Mulching. Thesis for Award PhD Degree at University of Wageningen, The Netherlands. 64pp.
- Lyimo, S. D., Mmbando, F. E., Xavery, P., Mushi, L., Sulumo, P., Mushi, P. and Owenya, M. (2003). Baseline survey report of Quality Protein Maize (QPM) in Northern Tanzania in 2003 crop season. 23pp.
- Mertz, E. T., Bates, L. S. and Nelson, O. E. (1964). Mutant gene that changes protein composition and increases lysine content of maize endosperm. *Crop Science* 145: 279-280.
- Moro, G. L., Habben, J. E., Hamaker, B. R. and Larkins, B. A. (1996). Characterization of the variability in lysine content for normal and opaque2 maize endosperm. *Crop Science*. 36: 1651 - 1659.

- Mwanga, J., Mussei, A., Mwangi, W. and Verkuil, H. (1999). Adoption of improved wheat technologies by small scale farmers in Mbeya District of Southern Highlands, Tanzania. In: *CIMMYT: The tenth regional wheat workshop for Eastern Central and Southern Africa. Addis Ababa, Ethiopia. CIMMYT: 39-45.pp.*
- Msuya, E. E, Hissano, S. and Nariu, T. (2008). Explaining productivity variation among smallholder maize farmers in Tanzania. Proceedings of XII World Congress of Rural Sociology of International Rural Association, Goyang, Korea. 30pp.
- Nathaniel, B. and Jonathan, K. (1997). Beyond Logit: Taking time seriously in Binary Time-Series-Cross-Section Models. *Working Papers 1017*. California Institute of Technology. [<http://www.nectec.ier.hit.ac.jp/BibEc/data/papers /cltsswopa 1017.htm>] Site visited on 14/8/2008.
- Nkonya, E., Schroeder, T. and Norman, D. (1997). Factors affecting adoption of improved maize seed and fertilizer in northern Tanzania. *Journal of Agricultural Economics*. 48 (1): 1 – 12.
- Ntege – Nanyeenya, W., Mugisa-Mutetikka, M., Mwanga, and Verkuil, H. (1997). An assessment of factors affecting adoption of maize production technologies in Iganga District, NARO, Uganda and (CIMMYT). 30pp.
- Nzomoi, J. N, Byaruhanga, J. K., Maritim, H. K. and Omboto, P. I. (2007). Determinants of technology adoption in the production of Horticultural export produce in Kenya. *African Journal of Resources Management* 1(5): 129 - 135.

- Okuro, J., Murithi, F. M., Verkuijl, H., Mwangi, W., Hugo, D. G. and Macharia, G. (2000). Factors affecting the adoption of maize production technologies in Embu district, Kenya. In: Mukisira E. A., Kinro, F. H., Wamae, J. W., Murithi, F.M., and Wasike, W. (eds.), collective and research for sustainable improved livelihoods. Proceedings of the 7th KARI Biennial Scientific Conference, Kenya, pp 45-55.
- Oluko, L. O., Asaba, J. F. and Kindness, H. M. (2000). Factors Affecting Uptake and Adoption of Outputs of Crop Protection Research in Peri-Urban Vegetable system in Kenya. In: Sustain Change: Proceeding of the Workshop on Factors Affecting Uptake and Adoption of Research Output. (Edited by Hainsworth, S. D. and Edengreen, S. J.) 21 - 23 June, 2000. Imperial College of WYE, Kent, UK, pp15 - 26.
- Padmaja, R., Bantilan, M. C. S., Parthasarathy, D. and Gandhi, B. V. J. (2006). Gender and social capital mediated technology adoption. Impact Series no.12. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 48pp.
- Pingali, P. L., Rozelle, S. D., and Gerpacio, R. V. (2001). The farmer's voice in priority setting: A cross-country experiment in eliciting technological preferences; *Economic Development and Cultural Change* 49(3): 591 – 609.
- Pingali, P. L. (2001). CIMMYT 1999-2000 World maize facts and trends. meeting world maize needs: Technological opportunities and priorities for the public sector. Mexico, 25pp.

- Pitt, M. M. and Sumodiningrat, G. (1991). Risk, schooling and the choice of seed technology in developing countries: A meta-profit function approach. *International Economic Review* 32 (2) 457-473.
- Prasanna, B. M., Vasal, S. K., Kassahun, B. and Singh, N. N. (2001). *Quality Protein R&D evaluation and impact assessment in agricultural and natural resources research*, SACCAR. 312 pp.
- Ransom, J. K., Paudyal, K. and Adhikari, K. (2003). Adoption of improved maize varieties in the hills of Nepal. *Agricultural Economics* 29: 299 – 305.
- Ransom, J. K., Palmer, A. F. E., Zambezi, B. T., Mduruma, Z. O., Waddington, S. R., Pixley, K. V. and Jewell, D. C. (Eds.) (1997). Maize productivity gains through research and technology dissemination. Proceedings of the Eastern and Southern Africa Regional Maize Conference, 5, Arusha Tanzania. 3 - 7 June, 1996.
- Rauniyar, G. and Goode, F. (2002). Technology adoption on small farms. *World Development* 20: 275–282.
- Regassa, E., Mwangi, W., Verkuijl, H., Hassena, M. and Alemayehu, N. (1998). Farmers Seed Sources and Seed Management in Chilalo Awraja, Ethiopia. IAR-Ethiopia, CIMMYT. 18pp.

Roberts, R. K., English, B. C. and Larson, J. A. (2002). Factors affecting the location of precision farming technology adoption in Tennessee. *Journal of Extension* 40(1). [<http://www.joe.org/joe/2009february/index.html>]. Site visited on 20.02. 2009.

Rogers, E. M. (2003). *Diffusion of Innovations*.

[http://en.wikipedia.org/wiki/Everett_Rogers]. Site visited on 20.02. 2009.

Rodgers, E. M. (1983). *Diffusion of Innovations*. Third Edition. The Free Press A Division of Macmillan Publishing Co., Inc. New York.

Semgalawe, Z. M. (1998) Household Behaviour and Agricultural Sustainability in the North-eastern Mountains of Tanzania. The case of Soil Conservation in the Northern Pare and West Usambara Mountains. PhD Thesis submitted to the University of Wageningen, Netherlands. 345pp.

Senkondo, E. M. M., Mdoe, N. S. Y., Mahoo, H. and Gowing, J. (1998). Factors affecting the Adoption of rain water harvesting technologies in western Pare Lowlands of Tanzania: *Tanzania Journal of Agricultural Sciences* 1(1): 81 - 89.

Shiferaw, B. and Holden, S. (2000). Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A case study in Andit Tid, North Shewa. *Agricultural Economics* 18: 233 – 47.

Sumberg, J., Gilbert, E. and Blackie, M. (2004). Income diversity, technology choice and agricultural research policy in sub-saharan Africa. *Development Policy Review* 22 (2): 131 – 146.

- Sunding, D. and Zilberman, D. (2000). The Agricultural innovation process: Research and technology adoption in a changing agricultural sector. Department of Agricultural and Resource Economics, University of California at Berkeley. 57pp.
- Tovignan, S., Vodouhe, D. and Dinham, B. (2001). Cotton pesticides cause more deaths in Benin. In “*Pesticides News*” No 52, June 2001. pp 12 – 14. PAN UK, London.
- Uaiene, R. N., Arndt, C. and Master, W. A. (2009). Determinants of agricultural technology adoption in Mozambique. National Directorate of Studies and Policy Analysis – Mozambique. Discussion Papers No. 67E. 29pp.
- URT (2003). The 2002 Population and Housing Census. General Report. Tanzania National Website [<http://www.Tanzania.go.tz/census/tables.html>] site visited on 13/04/09.
- Van den Ban, A.W and H. S Hawkins, (1996) *Agricultural Extension*, John Wiley and Sons, Inc. New York. 271pp.
- Villegas, E., Vasal, S. K. and Bjarnason, M. (1992). Quality protein maize – what is it and how was it developed? Chemists, Minnesota, USA. 21pp.
- Zhang, X., Fan, S. and Cai, X. (2002). The path of technology diffusion: Which neighbours to learn from? *Contemporary Economic Policy* 20: 470 – 78.

APENDICES

Appendix 1: The list of factors affecting adoption

Variable	Variable label	Expected sign	The theory and logic behind
(a) Farmers' demographic characteristics:			
X ₁ = AGEHH	age of the household head	+ or -	The age of a farmer can generate or erode confidence; in other words, with age, a farmer can become more or less risk-averse to new technology
X ₂ =GENHH	sex of the household head	+ or -	Female or male –headed households can have different adoption rates. Female headed households have less access to resources than male head households.
X ₃ =FEDUYRS	Education level of the farmer	+	Level of education is assumed to increase a farmers ability to obtain, process and use information relevant to adoption of technology
X ₄ = HHDSIZE	Number of people in the household	+	Large households will be able to provide the labour that might be required by new technology. Thus household size could be expected to increase the probability of adopting QPM technology
X ₅ = HHWONF	Number of household working in the farm	+	Household labour is the most dependable source of labor. Thus, large households with more labour supply are expected to adopt labour intensive technologies.
(b) Socio-economic factors			
X ₆ =FARSIZE	farm size	+	Large scale farmers have more freedom in allocating land to new crops. They also have access to information and credit since land is used as collateral.
X ₇ =FAFFD	Farmers attendance to farmers field day(Proxy to information)	+	. Farmers who have attended QPM field days are expected to have positive attitude to the adoption of QPM technology
X ₈ =FTRAI	Farmers attendance to farmer training	+	Farmers training is a key element in exposing farmers to new information and subsequently adoption

X ₉ =DEMTRIA	Participate in demonstration trials	+	Farmers participation in demonstration trials are expected to recognize the benefit of adopting the technologies demonstrated and hence to be more likely to adopt them.
X ₁₀ = LIOHH	Livestock ownership	+	Livestock stand for wealth in agro-pastoralists society. In general term, rich farmers are better placed in terms of risk bearing
X ₁₁ =FAVPR	Farmers preference for varietal attributes	+ -	Farmers subjective preferences for characteristics of new agricultural technologies affect their adoption decisions
(c) Institutional factors			
X ₁₂ =CREFAV	Credit facilities availability (Proxy to monetary incentive)	+	Access to credit can relax farmers' financial constraints and, in some cases, is tied to a particular technology package
X ₁₃ =EXTCO	Frequency of extension contacts/visit	+	The more visits the farmer get from extension agent the more informed about the innovations the farmer becomes. Contact with extension agents was hypothesized to increase a farmer's likelihood of adopting QPM technology.
X ₁₄ =SEEAV	Seed availability	+	Seed is an important input necessary for adoption of a technology. Availability of QPM seed by farmers was hypothesized to influence its adoption.
X ₁₅ = QPMKT	QPM marketability	+	Farmers' subjective perception on the characteristics of an innovation will influence the decision to adopt. Farmers who are informed on marketability and utilization alternatives of a variety will tend to adopt it faster than non –informed.

Appendix 2: Survey questionnaire

Factors Influencing Adoption of QPM Technology in Northern Tanzania

A. Identification

Questionnaire number _____ Enumerators Name _____

Date of Interview _____

Name of the farmer (head of household) _____

1. Village _____ 2. Ward _____

3. Division _____ 4. District _____

5. Region _____

B: Household characteristics

1. Age _____ (Years)

2. Gender _____ (1) Female (2) Male

3. Marital status _____ (1) Single (2) Married (3) Divorced (4) Widowed
(5) Separated

4. When did you start farming as an independent household?(Farming experience)
.....(years)

5. Have you ever attended any agricultural training _____(1)Yes (2)No

6. Have you participated in on-farm research trials? _____(1)Yes (2)No

7. If yes which group (programme)?

8. Have you attended farmer's field days organized by research, NGOs or Extension?
(1)Yes (2) No

9. What is the number of people currently living within your household?(Please indicate the number and their sex)

Age group	Number of household members	No. of members disaggregated by sex	
		Male	Female
Adults (≥ 15 years)			
Children (< 14 years)			
Total			

10. How many household members work on the farm _____

11. What is the total number of years in formal education? _____.(years).

12. Mention major important crops grown.

- 1).....2).....
 3).....4).....
 5).....6)..... 7)
8).....

13. Do you keep livestock? _____ (1) Yes (2) No

14. If yes please provide the following information with respect to livestock.

S/N	Type	Number
1	Cows	
2	Bulls	
3	Goats	
4	Sheep	
5	Pigs	
6	Chicken	
7	Others (specify)	

15. Do you have any of the following assets/services? *Tick where appropriate*

S/N	Asset	Yes/No
1	Car	
2	Motorcycle	
3	Bicycle	
4	Television set	
5	Tractor	
6	Telephone	
7	House for renting	

16. Do you hire labor for your farm operations? _____(1)Yes (2)NO

17. Apart from farming what are your other source of income? Please rank them in the order of importance

Activities	Rank
Dairy cattle keeping	
Charcoal making	
Fishing	
Carpentry	
Weaving (kusuka)	
Salaried employment	

Casual labor	
Business (specify)	
Others (Specify)	

D. Farm size and Land allocation patterns

18. What is the total size of your farm? _____ (acres)

19. Please provide the following information with respect to your farm last season (2007/200)

Area(acres)	Method of Acquisition	Current use(crop grown)

Key to farm acquisition:1=Purchased, 2=land lease, 3=Inherited 4=Rented 5=others

20. What is the relative importance of crops grown for food this season? Please rank your crops enterprise in order of importance.

1)..... 2)..... 3)..... 4)

21. What is the relative importance of crops grown for cash income this season? Please rank your crops enterprises according to order of importance.

1).....2)3)4.....

E. Knowledge of QPM

22 Are you aware of QPM? _____ (1) Yes (2) No

23. If yes when did you first hear about QPM? _____ (Year)

24. From whom did you first hear about QPM? _____ (1) Researchers/On farm trials (2) Extension agents (3) Farmers field Day (4) Others (Specify)

25. Have you ever participated in QPM on- farm trials/ demonstrations _____?

(1) Yes (2) No

26. If Yes, When? _____(Year)

27. Have you ever participated in QPM field Days? _____(1)Yes (2) No

28. If yes when? _____(year)

F.QPM Production

29. Have you ever planted QPM? _____ (1) Yes (2) No

30. If Yes when? _____(Year)

31. What was the first source of QPM seed?

32. Did you grow QPM in the last season (2007/2008)? _____(1)yes (2) No

33. Was QPM seeds available? _____(1)yes (2)No

34. If No why? (Please give reasons).....

35. Are you a member of any farmers' organization? ____ (1) Yes (2) No

36. If yes mention the name of the organization. _____

37. What are the advantages of being a member? (List them).....

.....

.....

38. Regarding QPM technology use and seasons, please provide the following information

Area under QPM (acres)	2004/5	2005/6	2006/7	2007/8

39. What is your future plans concerning the total area under QPM? _____

(1) Increase (2) Reduce (3) No change (4) About to start.

40. Please give reasons for the above answer

.....

41. What was your means of land preparation for QPM last season? _____

(1)Tractor (2) Hand hoe (3) Ox- plough

42. Do you intercrop QPM with other crops? (_____ (1) Yes (2) No

43. If yes, what crops intercropped with QPM?.....

44 Do you purchase input for QPM production? _____(1)Yes (2)No

45. If Yes, What type of inputs do you purchase please mention (1)

.....(2).....

(3)..... (4)

(5) Other (specify).....

G. Source of information on Maize management practices

45. Please provide the following information with respect to your source of information?

Management practices	Source
Maize varieties	
Planting /spacing	
Intercropping	
Fertilizer use	
Weed management	
Pest &Disease control	
Storage practices	

Source.1= Radio 2= Newspaper 3=extension staff 4=neighbors 5=Farmers organization
6=researchers 7=NGOs 8= Others (specify)

H: Marketing of QPM

46. Did you sell maize last season? (_____) (1) Yes. (2) No

47. Do you ever sell QPM from your harvest? _____(1)Yes. (2) No 41. If yes please provide the following information.

Year	Amount sold		Amount Consumed		Price(Tsh) per kg	
	QPM	Normal Maize	QPM	Normal Maize	QPM	Normal Maize
2004/5						
2005/6						
2006/7						

48. To whom do you sell QPM? _____ (1) Traders (2) Millers (3) Others (specify)

49. Price perception by the farmer. _____(1) Good. (2) Fair. (3) Poor

I: Access to Extension services

50. Do you access extension services _____(1) Yes (2) No

51. If Yes, how many Extension visits /contacts have you had for the last 12 months?

J: Access to credit

52. Are there credit societies in your place? _____(1) Yes. (2) No.

53. Are you a member of any credit society? _____(1) Yes. (2) No.

54. Are the credit services available? _____(1)Yes. (2) No.

55. If No what are the difficulties in obtaining credit?

.....
.....

56. If yes, please complete the following table

Type of credit (A)	Source of credit (B)	Constraints (C)

- | (A) | (B) | (C) |
|-------------------|------------------------|------------------------|
| 1. Seeds | 1. Cooperative society | 1. Unavailability |
| 2. Fertilizers | 2. Commercial Banks | 2. Lack of information |
| 3. Cash | 3. Other farmers | 3. Bureaucracy |
| 4. Implements | 4. SACCOS | |
| 5. Others specify | | |

K. Consumption of QPM

57. What are the uses of QPM in your family?
-
-
58. How often does your family consume QPM _____(1) very often
 (2)Occasion (3) never consumed

L: Constraints to QPM production and marketing.

60. Generally what problems do you face in QPM production? (Begin with the most important constraint)
- 1) 2)
- 3) 4)
61. Do you face problems in QPM Marketing? _____(1)Yes (2) No
- 62.If Yes please, mention them.
- 1)3)..... (5).....
- 2)4).....

M: Recommendations to QPM production and marketing.

63. What do you recommend in order to improve QPM production and marketing

.....
.....
.....

Thank you very much for your cooperation

Appendix 3: Importance of maize in the diet of individuals in selected African countries

Country	% total Calories	% total Protein
Lesotho	58	55
Zambia	57	60
Malawi	54	55
Zimbabwe	38	46
Kenya	36	34
Tanzania	33	33
South Africa	33	33
Togo	25	29
Cape Verde	24	26
Swaziland	23	24
Mozambique	22	31
Ethiopia	21	17
European union	1	1
United States	3	2

Appendix 4: Normal endosperm flint type maize (A), normal endosperm dent type maize (B), opaque-2 maize (C) and Quality Protein Maize (D).

