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CENTER OF FOOD SECURITY STUDIES

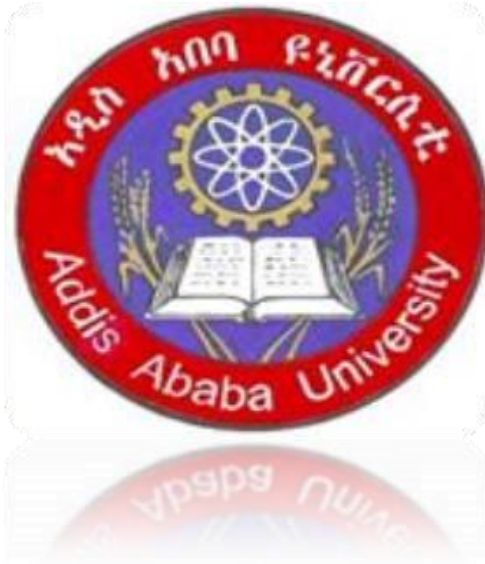
CONTRIBUTION OF RICE TECHNOLOGY ADOPTION IN ENSURING
RURAL HOUSEHOLD FOOD SECURITY:
THE CASE OF CHAWAKA DISTRICT, WESTERN OROMIA, ETHIOPIA

BY

LENSA GIRMA CHEMEDA

JUNE, 2019

ADDIS ABABA



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BY

LENSA GIRMA CHEMEDA

ADVISOR: Dr ADMASU SHIBRU

**A THESIS SUBMITTED TO CENTER OF FOOD SECURITY STUDIES OF
THE COLLEGE OF DEVELOPMENTAL STUDIES, ADDIS ABABA
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SECURITY AND DEVELOPMENT**

**JUNE, 2019
ADDIS ABABA**

ADDIS ABEBA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

As research advisors, I hereby certify that I have read and evaluated the thesis prepared by **Lensa Girma Chamade** under my guidance, which is titled “*Contribution of Rice Technology Adoption in Ensuring Rural Household Food Security: The Case of Chawaka District, Western Oromia, Ethiopia*”. I recommend that the thesis be submitted as it fulfills the requirements for the degree of Masters of Science in Food Security Studies.

Admasu Shibiru (Ph.D) _____

Advisor

Signature

_____ Date

As members of the Examining Board of this thesis open defense, we certify that we have read and evaluated the thesis prepared by **Lensa Girma Chamade** under my guidance, which is titled “*Contribution of Rice Technology Adoption In Ensuring Rural Household Food Security: The Case of Chawaka District, Western Oromia, Ethiopia*”. And recommend that it is acceptable as a thesis required for the degree of Masters of Science in Food Security and development.

Signed by the examining committee

Name, Chairman

Signature

Date

Name, Internal examiner

Signature

Date

Name, External examiner

Signature

Date

Final approval and acceptance of this thesis is contingent upon the candidate’s submission of the final copy of the thesis, incorporating all the comments by Examining Board, to the Council of Graduate Studies (CGS) through the Center Academic Committee (CAC) of the center.

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Name: Lensa Girma Chamade

Signature.....

Place: Addis Abeba University

Date of Submission: -----

Dedication

Dedicated to my beloved family Mr. Girma Chamade, Mrs. Tejitu Chemedda, Mr. Nabek Girma, Mr. Bezu Girma, and Miss Lelise Tezera thank you for your unconditional love.

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The first gratefulness goes to the Almighty God, who is helping me in every part of my life, including this research work. Then I would like to thank many people who have been supporting me in accomplishing this study work. My greatest thanks and heartfelt appreciation go to my supervisors, Dr. Admasu Shebru for their valuable guidance and support throughout the whole research process.

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List of acronyms and abbreviations

CSA	: Central Statistical Agency
DPPC	: Department of Planning and Economic Development, Disaster Prevention and Preparedness Commission
EUT	: Expected Utility Theory
FAO	: Food and Agriculture Organization
FGT	: Foster, Greer and Thorbeck
FTC	: Farmer training center
GDP	: Gross Domestic Product
GIS	: Geographic information technology
IRV	: Improved rice variety
HFBM	: House Hold food balance Model
LPM	: Linear probability model
MoFED	: Ministry of Finance and Economic Development
NGO	: Non- government organization
OLS	: Ordinary list Square
PPS	: Probability Proportional to Size
SD	: Standard Deviation
SPSS	: Statistical Package for Social Sciences
SSA	: Sub-Sahara Africa
TLU	: Total Livestock unit
TPB	: Theory of Planned Behavior
TRA	: Theory of Reasoned Action
UN	: United Nations'
VIF	: Variance inflation factor

Abstract

The objective of this study was to assess the role and contribution of improved rice technologies in ensuring rural households' food security enhancement in Chewaka district in Oromia regional state. For this study three kebelas were randomly selected and 178 respondents were sampled. Both descriptive and econometrics analysis were employed. In order to evaluate household food security, household food balance model were employed, Tobit model was used to assess rate and intensity of adoption and logit model was used for determining factors affecting household food security and adoption of rice technology and also ordered econometric analysis took place to categorize and determine the factors affecting household food security status. Results of descriptive analysis showed that adopters of improved rice varieties as compared with non-adopters are characterized by having better agricultural extension and educational status, younger age, smaller family size than none adopter four variables are found to significantly determine adoption and intensity of improved rice varieties. Those are education level, membership in cooperative, access to credit affects positively while family size affects negatively. Factors affecting food security of household indeed adoption of improved variety, membership in cooperative are those which have positive impact and proportion of land for IRV training has negative impact. Finally, household food security classified into four categorized by ordered logistic regression in to food secured, moderately in secured, severely in secured and food in secured. The study concludes that socioeconomic factor had significant effect on adoption of IRV whereas they also influence household food security status. The research Recommended that recommends that rice production programs should be designed to improve the intuitional and socioeconomic characteristics of rice farmers in the area and promotion of Agricultural mechanization and food science research interventions be strengthened more Seed multiplication and dissemination of improved varieties should be given due attention.

Keywords: Food security, intensity, adoption of technology and IRV

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

By 2030, ensuring sustainable food production systems and implement resilient agricultural practices that increase productivity and production, and help to maintain ecosystems, which strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality is the goal of SDG. In the Sustainable Development Goal to “End hunger, achieve food security and improved nutrition and promote sustainable agriculture” is the main concern in order to reduce poverty and hunger a lot have been done in past millennium development plan for instance in 2004 the declaration of International Year of Rice can see as a big example. In 2002, rice was the supply of over five hundred calories per person per day forever three billion individuals. Furthermore, rice cultivation is that the principal activity and supply of financial gain for over a hundred million households in developing countries around the continent and geographical region.

In the world of nowadays, food insecurity could be a widespread development despite the very fact that food security is taken into account as an elementary right. Food security has been a significant concern particularly in Africa wherever getting ready to thirty million folks are food insecure attributable to frequent droughts, armed conflict, corruption and therefore the management of food supplies, environmental degradation and trade policies affecting most African countries (Benson, 2004).

The biggest proportion of the poor living in a state of acute poverty is found in Africa South of Sahara (Todaro, 1997) one serious manifestation of poverty in Sub-Saharan Africa (SSA) is the usual occurrence of food insecurity in the region. According (World Bank, 1996) it is estimated that over 100 million people in Africa are food insecure. More than half of the foods insecure are clustered in seven SSA countries: Chad, Zaire, Uganda, Mozambique, Zambia, Somalia, and of course Ethiopia. In these countries, over 40 percent of the populations are estimated to be food insecure. Accordingly, in Ethiopia food insecurity is seen as the most important feature of development challenges. The agricultural sector is the backbone of the Ethiopian economy, making multifaceted contributions to the economy. The performance of agriculture, however, in terms of feeding the country’s population, which is growing at about 2.9 per cent per annum, is poor (Kidane *et al.*, 2005).

According to (Ginjo ,2000) adverse climate changes (such as drought) combined with high human population pressure, environmental, technological and institutional factors, etc., have led to a decline in land holding size per household, soil erosion and decline in productivity increases the problem of food insecurity. Agricultural growth is seen as a best-bet strategy for achieving food security because of the fact that agriculture is central to the livelihood of more than half of the world's population. Growth in agricultural production can reduce food insecurity by increasing the amount food available for consumption. This is particularly important for rural consumers whose food entitlement is mainly based on own production (Adekambi *et al.*, 2009).

Agricultural production can be increased through intensification (i.e. through expansion of farm lands) or intensification (i.e. by using more inputs and technologies per unit of land). However, intensification is not a viable strategy to increase agricultural production in most of the food insecure countries where high population pressure is a critical bottleneck. Where land is scarce, intensification, which entails investments in modern inputs and technologies, is a better option to increase agricultural production and reduce food insecurity. This option was effectively implemented by several Asian countries in 1970s and was dubbed the “green revolution”.

New agricultural technologies and improved practices play a key role in increasing agricultural production (and hence improving national food security) in developing countries. Where successful, adoption of improved agricultural technologies could stimulate overall economic growth through inter sectoral linkages while conserving natural resources (Kidane *et al.*, 2005) Given the close link between food insecurity, farming and environmental degradation the impact of cultivation practices has received significant attention in the last two decades. New cultivation techniques have been introduced in many countries to enhance productivity in the agriculture sector.

Rice is among a few crops which have received special attention from the Ethiopian government and NGOs operating in the country. In this regard, the government has paid attention to research and extension of rice technologies. Studies to develop improved rice technologies have been conducted since the 1980s with the assistance of international research centers and foreign donors resulting in several improved rice varieties and management practices. The role of the national agricultural research system is immense in the process of development of improved rice varieties.

The improved rice varieties (together with improved agronomic practices) have been introduced and disseminated to rice farming communities in different parts of the country through the extension system operated by the government.

Chewaka district is one of rice producing districts which has benefited from researches on rice and subsequent transfers of improved rice varieties and agronomic practices. However, there is no information on the extent to which the so far developed rice technology has been effective in meeting their stated objectives of attaining household food security in the study district. Therefore, this study was designed to fill this research gap. Specifically, the study deals with the analysis of the contribution of growing improved rice technologies on food security given that the varieties are planted using the recommended planting method.

1.2. Statement of the problem

Poverty and food insecurity remain as the major challenges to archive economic development in Ethiopia and special in the rural area of the country. This is due to the subsistence nature of agriculture, mere dependence on rainfall and existing backward technology, which made farmer highly vulnerable to famine and food insecurity. Also, the country has faced severe food shortages within the past two decades and is on constant threat of famine. According to (FAO,2014) Sub-Saharan Africa is the worst of all regions in prevalence of undernourishment and food insecurity ;Ethiopia (ranking no.1) is the worst of all African countries as nearly 33 million people are suffering from chronic undernourishment and food insecurity. This indicates that Ethiopian has one of the highest levels of food insecurity in the world in which more than 35% of its population is chronically undernourished. Agricultural productivity in Ethiopia is known to be the lowest among African country. One major reason for the low agricultural productivity in Ethiopia is the low rates of adoption of improved agricultural production technologies. In Ethiopia 53,106.79 hectare of land covered by rice from this land 1,510,183.30 qt /hectare is produced out of which 6,100.19 rice land found in Oromia regional state and 166,511.44 tone/hectare rice was produced (CSA, 2017/18). According to WHO (2009) the food security and nutrition situation in Oromia region has rapidly deteriorated in (West Arsi, Bale, East and West Hararghe zones).

From the total food production in Ethiopia, cereal constitutes the largest share. The increase in cereal production in the last decade has contributed to the decrease in the prevalence of undernourishment. The increase in the production however, does not decrease correspondingly the

number of undernourished people since the population has been growing at the same time. Rice is one of the market oriented and strategic crops in the rice producing areas of Ethiopia and a staple food crop for many rural households particularly for rural communities in Chewaka district. It is a productive crop next to maize in the country (CSA, 2003) and considered as the “Millennium crop” which is expected to contribute to ensuring food security in Ethiopia (Hadush, 2015). However, the productivity of the crop is low as the farmers in the district have been using local varieties that are genetically low yielders.

There have been few studies conducted to assess determinants of rice adoption in areas where rice production and research was extensively conducted in Ethiopia (Afeework & Lemma, 2015). Although the rate of adoption of improved agricultural technologies have been studied in Oromia, specific rice adoption studies have not been studied

In spite of its importance, less attention is given to adoption studies and impact assessment in the today’s research system. Technology adoption and intensity of use are constrained by a series of factors. Understanding the nature of these factors and quantifying the extent to which each of these factors contribute to, or hinder adoption of these technologies is of paramount importance to enhance technology uptake. Unfortunately, despite the continuous efforts to generate and disseminate the technologies every year, literatures related to adoption and use intensity of rice technologies in Ethiopia is scanty. In spite of the importance of identifying and documenting the underlying factors that facilitate or hinder technology adoption process, information with regard to adoption of the technologies and locally specific factors influencing adoption and intensity of use of these technologies in the district, in particular, was not empirically studied and documented. Hence, the researcher has taken the initiative to determine the extent of rice technology adoption and factors that influence adoption and intensity of use these technologies for future direction. In addition, this study aspired at assessing the extent of food insecurity, to identify its determinants and food security due to rice technology adoption in the study area.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was to investigate the role and contribution of adoption improved rice technologies in ensuring rural households' food security enhancement in the western Oromia in general and in Chewaka district specifically in order to draw important conclusions and policy implications for future intervention.

1.3.2. The specific objectives

Specific objectives of this study were to:

- assess the rate and intensity of adoption of rice technology in the study district
- examine and identify the trend of rice production and its food value in the study area
- identify factors that could determine rural household food security in the study areas

1.4. Research questions and hypothesis

For a specific study of adoption of improved rice technologies linking with the issues of food security, a number of questions was raised and an attempt was made to address the survey study.

The major research questions were:

1. What are the factors influencing farmers decisions to adopt improved rice technologies in the study area?
2. What are factors that could determine rural household food security in the study areas?
3. What is the position of rice adopters' in terms of crop production, income and dependence on food aid when compared with their non- adopters' counterparts?
4. To what extent has household food security been addressed through adoption of improved rice technologies?
5. What are the major problems and constraints in rice production in the study district?
6. What measures will be required to improve the households' food security status in the study areas?

1.5. Significance of the study

In developing countries like Ethiopia, agriculture is a strong option for spurring growth, overcoming poverty, and enhancing food security, and this has necessitated the need to increase agricultural productivity through the introduction and use of improved agricultural technologies (World Bank, 2008). A number of area- and commodity specific studies of technology adoption conducted in Ethiopia have focused minimally on the link between the adopted technologies and food security, their interactions, and the effect of the former on the latter. Some of the latest adoption studies in Ethiopia include the evidence provided by Hassen *et al.*, (2011). To this end, identifying, analyzing and understanding the role and contribution of growing improved rice technologies in enhancing rural households' food security in the western Oromia in general, Chewaka district specifically would contribute to the sustainable improvement of household food security, better management of rice production systems and executing the government strategy of poverty reduction. It is also important for policymakers to know the benefit of new technologies and the critical factors that could accelerate their use. This could facilitate efficient allocation of major resources for research, extension and development programs. It is expected that this study would serve as a springboard (facilitator) to undertake detailed and comprehensive studies in the country.

1.6. Scope and Limitations of the research

This study is only a piece of a huge effort to unfold realities regarding, food security situation, agricultural technology acceptance and its consequences. Therefore, its scope is limited in terms of coverage and depth owing to financial and time resources available. It is limited to only contributions of rice adoption enhancing rural households' food security and this study was also limited to Chewaka district in terms of area coverage. Nevertheless, the result of this study will be used as a reference for other similar areas.

1.7. Organization of the research

This research consists of five chapters. The remaining part is organized as follows. Chapter two reviews literature related to the research topic. Methodological issues including the study area description are presented in chapter three. The fourth chapter presents the results of the study and discusses it in comparison with the results of similar studies. The final chapter presents the main findings, conclusions and recommendations made based on the study.

CHAPTER TWO: RELATED LITERATURE REVIEW

2.1. Theoretical Foundation

According to Feder *et al.*, (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. (Dasgupta, 1989) noted that adoption, however, is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs.

Adoption commonly refers to the decision to use a new technology or practice by economic units on a regular basis. (Rogers, 1983) defines the adoption process as the mental process through which individual passes from first hearing about an innovation or technology to final adoption. This indicates that adoption is not a sudden event but a process. Farmers do not accept innovations immediately; they need time to think over things before reaching decision. Diffusion often refers to spatial and temporal spread of the new technology among different economic units. Therefore, adequate understanding of the process of technology adoption and diffusion is necessary for designing effective agricultural research and extension programs (Feder and Zilberman, 1985).

Among many other definitions, the one given by Rogers, (1983) is widely used in several adoption and diffusion studies. He defined diffusion (aggregate adoption) as the process by which a technology is communicated through certain channels over time among the members of social system. Rogers, (1983) then defined adoption as use of a new technology by a farmer at a given period of time. This definition can be extended to all economic units in the social system. Diffusion often refers to spatial and temporal spread of the new technology among different economic units. Therefore, adequate understanding of the process of technology adoption and diffusion is necessary for designing effective agricultural research and extension programs (Feder and Zilberman., 1985).

Feder and Zilberman (1985) distinguished individual adoption (farm level) from aggregate adoption. Individual adoption was defined as the degree of use of a new technology in long run equilibrium when the farmer has full information about the new technology and its potential impact. Aggregate adoption (diffusion) was defined as the process of spread of technology within a region. This implies that aggregate adoption is measured by the aggregate level of specific new

technology within a given geographical area or within a given population. The adoption decision also involves the choice of how much resource (i.e. land) to be allocated to the new and old technologies if the technology is divisible (e.g. improved seed, fertilizer and herbicides), the decision process involves area allocations as well as level of use or rate of application (Feder and Zilberman, 1985).

A distinction has to be made between technologies that are divisible and that are not divisible with regard to the measurement of intensity of adoption. The intensity of adoption of divisible technologies can be measured at the individual level in a given period of time by share of farm area under the new technology or quantity of input used per hectare in relation to the research recommendations (Feder and Zilberman, 1985). On the other hand, the extent of adoption of non-divisible agricultural technologies such as tractors and combine harvesters at the farm level at a given period of time is dichotomous (use or no use), and the aggregate measure becomes continuous. The rate of adoption is defined as the percentage of farmers who have adopted a given technology. The intensity of adoption is defined as the level of adoption of a given technology.

Food security concepts

There are many definitions of food security. The most internationally used definition is that food security exists when all people at all times have both physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (WB, 1986; FAO, 1996). FAO explains that food security consists of the following four pillars: food availability, physical and economic access, stability and utilization.

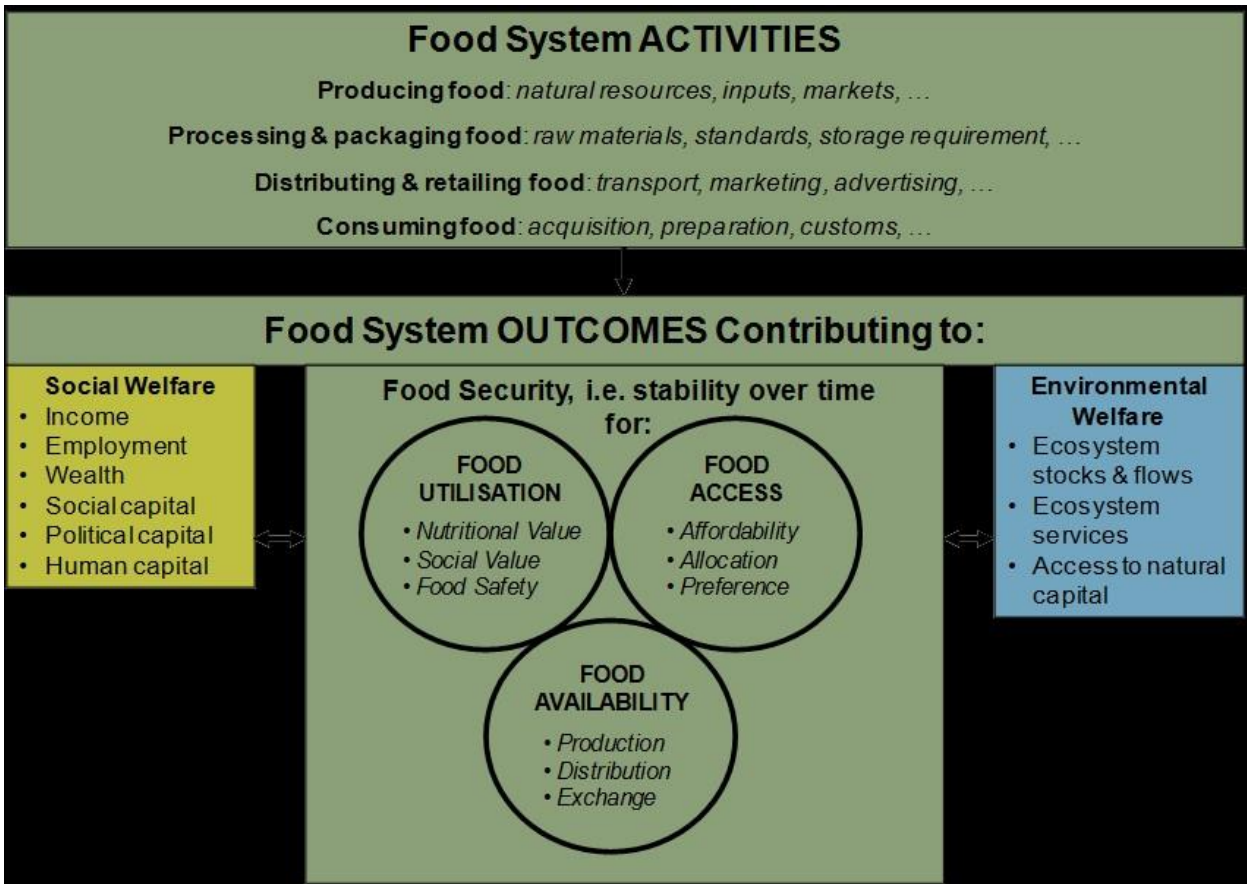


Figure 1: Food System Activities (Source: Ingram 2011)

2.2. Theoretical literature review

Theories of adoption of innovation

Most of the theoretical models on adoption of innovation have tended to present discipline guided explanations to the adoption decision, although adoption is subject to a combination of social, economic, psychological, as well as cultural factors (Boahene et al., 1999; EdwardsJones, 2006).

The purely economic literature regarding farmers' decisions is based on normative theory and on the assumption that decisions can be modeled only in terms of the individual acting to maximize profit (Austin et al., 1998; Willock et al., 1999). However, this literature cannot capture the full complexity of farmers' decisions (Austin et al., 1998). Additionally, such models fail to recognize that farmers' behavior is not driven only by the maximization of profit (Willock et al., 1999). In the field of agricultural economics, farmers' decisions and behaviors have been studied by two

main different approaches: one is based on purely economic models, where Expected Utility Theory (EUT) plays a central role. The second approach is based on socio-psychological theories, where psychological constructs explain farmers' behavior, for instance the decision to adopt an innovation. One of the most relevant theories used by researchers to understand farmers' behavior was developed by Fishbein and Ajzen (1975), the Theory of Reasoned Action (TRA). TRA was extended by Ajzen (1991), resulting in the Theory of Planned Behavior (TPB).

Expected utility theory (EUT)

This theory assumes the pure economic view of theory of adoption of innovation. Expected Utility Theory (EUT) states that a farmer compares the innovation with the traditional technology and adopts it if the expected utility from adopting exceeds the expected utility of the traditional technology (Batz *et al.*, 1999). Although the utility function is unobserved, the relation between the expected utility corresponding to each alternative is postulated to be a function of the vector of observed variables and an error term (Adesina and Zinnah, 1993; Batz *et al.*, 1999). Using econometric models, mainly logit, probit and Tobit, empirical studies analyze the impact of different and diverse variables on individual adoption decisions (Batz *et al.*, 1999).

Theory of reasoned action (TRA) & theory of planned behavior (TPB)

To understand the factors influencing adoption of technology, Information Systems Research has taken a wider perspective to study the factors affecting adopter's behavior to adopt a technology. Fishbein and Ajzen's (1975) theory of reasoned action (TRA) provides a firm theoretical foundation for the stream of Information Systems Research with an objective to predict behavior of individuals to adopt a particular technology. The theory of reasoned action (Ajzen&Fishbein, 1980) was first introduced in 1967 by Fishbein in an effort to understand the relationship between attitude and behavior. It attempts to explain the relationship between beliefs, attitudes, intentions and behavior. According to the theory of reasoned action, the most accurate determinant of behavior is behavioral intention. The direct determinants of people's behavioral intentions are their attitudes towards performing the behavior and the subjective norms associated with the behavior. Attitude is determined by a person's beliefs about the outcomes or attributes of performing a specific behavior (that is, behavioral beliefs), weighted by evaluations of those outcomes or attributes.

Models for analyzing adoption of technologies

Generally, it is assumed that farmers' decision in a given period of time and space are derived from maximization of expected utility or expected profit subject to resource constraints.

Therefore, adoption decision depends on farmers' discrete choice of a new technology from a mix including the traditional technology and a set of components of a new technology (Feder and Zilberman, 1985). To answer the question of what determines whether a particular technology is adopted or not and intensity of adoption, most of the adoption of agricultural innovation studies used static rather than dynamic models.

Static adoption models

The static model refers to farmers' decision to adopt an improved technology at a specific place and specific period of time. This model attempts to answer the question of what determines whether a particular technology is adopted or not and what determines the pattern of adoption at a particular point in time. The results of these models are often contradictory regarding the importance and influences of certain variables (Ghadim and Pannel, 1999). One limitation of the static model is that it does not account for time in adoption process or for the farmers' activity to learn to improve their technical efficiency in growing and marketing crops (Hailu, 2008). These weaknesses are addressed in using a dynamic adoption models.

Dynamic diffusion models

Unlike static adoption models, dynamic diffusion models allow the parameters of diffusion that determine the diffusion path to change over time. Dynamic diffusion methods relax some of the assumptions of static diffusion models by allowing for this adoption and variations in the rate of acceptance (slope), and helping directly identify the variables significant to the adoption of an innovation. The majority of adoption studies are continued to be a static binary setting of logit or probit models such as (Polson and Spencer, 1991; Jonsen, 1992). In these models the adoption decision is merely dichotomous (whether to adopt or not), where a functional relationship between the probability of adoption and a set of explanatory variables is estimated econometrically using logistic distribution for the logit procedure and normal distribution for the probit procedure. The logit/probit methods investigate the effects of repressors on the choice to use or no to use but it does not measure the degree or intensity of adoption (Feder and Zilberman, 1985). Therefore, the

alternative static econometric procedure such as the Tobit (Tobin, 1958) was used to analyze quantitative adoption decisions when information on the intensity of adoption is available.

However, in working with continuously measured dependent variables such as quantity of area, some of the data points will have a zero value (for non-users). In this case, a dependent variable is censored where information is missing for some range of the sample. Information on the dependent variable is available only if the dependent variable is observable, the dependent variable is described as truncated (Kennedy, 1992). The Tobit model provides coefficients that can be further disaggregated to determine the effect of a change in the *i*th variable or changes in the probability of adopting the new technology and expected intensity of use of the technology. However, a study by Dong and Saha (1998) indicated that a Tobit model imposes restrictions that the variables and coefficients determining decisions whether to adopt and how much to adopt are identical.

Other alternatives to analyze farmers' adoption decisions include the use of double hurdle models, which take in to account zero observations (Cragg, 1971, Heckman, 1976). The choice of a model is important because it influences the empirical results obtained (Jones and Yen, 1994). The Tobit model assumes that decision regarding adoption and intensity of use are related. However, studies by (Cragg, 1971) on the demand for durable goods and (Coady, 1995) on fertilizer use indicated that such decisions might not be intimately related. The (Heckman, 1976) model is also another most restrictive type of the double hurdle model available because it assumes that none of the zeros for the non-adopters are generated by the adoption decisions (i.e. first hurdle dominance) so that standard Tobit censoring is irrelevant (Jones, 1989)).

So for this study the dynamic diffusion theory is best fit because of it give better explain about technology adoption that most of the times focus on the decision of farmers to adapt that technology also the dynamic diffusion modal flows econometrics models such as logit, probit and Tobit for better explanation of variables.

2.3. Empirical literature on rice technology adoption

As stated in the study of Bethuel and Edward (2017), Technology adoption (time-saving equipment, modern seeds etc.) has been touted as the key to improving productivity and addressing poverty and food insecurity. However, as in the rest of sub-Saharan Africa, East Africa has low adoption rates of agricultural technology and smallholder farmers remain poor and largely

concentrated in rural areas. Currently, smallholder farms account for around 75% of agricultural outputs, with average farm sizes of 2.5 hectares producing mainly for home consumption and using traditional technologies. Furthermore, less than 4% of the total land area is irrigated. As such, East African agriculture is characterized by low productivity. Empirical studies argue that adoption of agricultural technologies can reduce poverty both directly and indirectly (Becerril & Abdulahi, 2010; 2007). The direct effects include the productivity gains and low cost of production which can improve income of the adopters while the indirect benefits from the technology adoption may come in the form of increased supply which may lower food prices. The increased productivity may also stimulate demand for labor which may translate into increased employment and earnings for the poor who usually supply labor to the farms. Adoption of improved technology has been identified as a key measure towards achieving food security. Peasant farmers have the potential to enhance their welfare as well as their food security situation if they make use of improved agricultural technologies (Mendola, 2007).

As study conducted in Ethiopia the adoption of agricultural technologies depends on different demographic and socio-economic factors. As stated in Croppenstedt et al. (2003) studied on determinants of fertilizer adoption in Ethiopia based on a survey covered 6147 cereal households from four regions. By applying double-hurdle model, they found that access of fertilizer, availability of credit, household size; formal education and value-to-cost ratio are the major factors that affect households' decision for fertilizer adoption. Also study by Dadi et al. (2004) studied on the duration analysis of technological adoption in Ethiopian Agriculture by using accelerated lifetime model. The estimated models suggest that economic incentives such as prices are appear to be the most important determinants for the speed of adopting new technologies followed by oxen ownership and infrastructural factors.

According to study conducted by Audu *et al.*, (2008), opined that rice is the second largest crop produced in the world after wheat. This view is countered by Fashola *et al.*,(2007), who reported that rice is the fourth largest crop produced after sorghum, millet and maize .according to the national rice research and document strategy (2009), Rice is among the important cereal crops grown in different parts of Ethiopia as food crop. The country has immense potentials for growing the crop. It is reported that the potential rice production area in Ethiopia is estimated to be about 5.4 million hectares. The trend in the number of rice producing farmers, area allocated and production shows high increase rate especially since 2006. The number of farmers engaged in rice

production has increased from about 53 thousand in 2006 to about 260 thousand in 2008. Similarly, the area allocated has increased from about 18 thousand in 2006 to about 90 thousand ha in 2008 along with production increase from about 150 thousand tonnes in 2006 to about 286 thousand tonnes in (2008).

Also study by Bull, (1988) estimated that about 3.5 million hectares of vertisols is found in the Amhara region, which remains waterlogged for most of the year and possible to produce food crops in these soils through better water management (drainage) and use of water loving crops such as rice. According to Alemu *et al.*, (1998), many variables can influence farmers' awareness and adoption of new varieties: human capital variables such as literacy; farm size; information sources such as agricultural extension or the research station; and distance from seed sources. Farmers with more land had a higher probability of adoption, probably because they are wealthier and have more land to experiment with improved wheat varieties. Extension visits also resulted in a higher probability of adoption by raising farmers' awareness of new wheat varieties and providing information about agricultural practices to accompany them which may also influence adoption of rice technology.

Role of rice in Ethiopian food security

The cultivation of rice has begun in the early 1970's and then after expanded to different parts of the country. The crop offers several advantages to farmers compared to other field crops grown in the country. It gives more yields per unit area, and contributes a lot to food security. At the current productivity level at farmers' fields, paddy rice produced from a hectare of land can sustain 4 more people. Furthermore, the crop is valued for its variety of uses e.g. in the preparation of local food and beverages (enjera, dabbo, genffo, kinche, shorba, tella, and katikalla) either alone or mixed with other crops such as teff, millet, wheat, barley, and maize. In general, rice could be considered as one of the best and the cheapest alternative technology available to farmers for efficient utilization of their scarce resources, especially the land and water in swampy and water logged environments. In addition, owing to its length of growing period, rice is suitable for sequential cropping. Rice is also primarily a cash-earning crop. The rice bran, hull, and straw are used as animal feeds. Furthermore, the straw is used for house fetching (Assefa, 2012).

Rice extension program in Ethiopia

The current rice extension package includes best agronomic practices and technologies i.e. improved varieties, fertilizers, and chemicals required to control pests; So far, 15 improved varieties (12 for rain fed and 3 for irrigation) are released and has increased the productivity from 2.35 t/ha in 2008/09 to 3.2 t/ha in 2011/12. This is encouraging but still more needs to be done to close the great gap between research and actual farmers' productivity levels (Kebebew *et al.*, 2011).

Rice production potential in Ethiopia

Among the target commodities that have received due emphasis in promotion of agricultural production, rice is considered as the “Millennium crop” expected to contribute to ensuring food security in the country. Even though, it is a recent introduction to the country, rice has shown promise as to be among the major crops that can immensely contribute towards ensuring food security in Ethiopia. The country has vast suitable ecologies for rice production along with the possibility of growing it where other food crops do not do well. Based on GIS techniques and agro-ecological requirements of rice, the potential rain-fed rice production area in Ethiopia is estimated to be about thirty million hectares. The importance of rice as a food security crop, source of income and employment opportunity due to its relative high productivity as compared to other cereals is recognized by farmers as well as private investors who frequently request for improved varieties for different ecosystems. (Teshome and Dawit, 2011).

Impact of agricultural research on poverty reduction and food security

The analysis indicates an average return of about 60% per year for research in developing countries (Alston *et al.*, 2000). A study by Thirtle *et al.*, (2003), on the impact of research led agricultural productivity growth on poverty reduction in Africa, Asia and Latin America, revealed that research led technological change in agriculture generates sufficient productivity growth. It indicates high rates of return in Africa and Asia and has a substantial impact on poverty reducing the number by 27 million per year. The per capita ‘cost’ of poverty reduction by means of agricultural research expenditures in Africa is \$144 and \$180 in Asia (Seck, *et al.*, 2013).The relationship between agricultural research and rural poverty in India and China was studied by Fan *et al.*, (2003). The results indicated that rice varietal improvement research has contributed tremendously to increase

rice produce, accounting for 14-23% of total production value over a two decade period. The research also revealed that agricultural research has helped reduce large numbers of rural poor.

2.4. Research gap

A lot of researches has been done in crop production technology there were a little focuses contribution of adoption of improved rice technology in the country rather than other crops. Even though rice accounts about 18,000 ha of land from total cultivated land there was a slight attention given about its importance and it was not recognized as significant crop that could change the livelihood of farmers. For instance study on determinants of rice technology adoption and rice production there is no interests shown on its impact on food security status of household. Other gap identified was that the studies conducted before only shifts there focuses on one part of the country where there is potential of rice production know as (fogora) but now days rice also produce in non-water logging areas (upper land rice) for this fact chewak area rice production can be taken as an example were there was high capacity of rice production as much as fogora. So far there was no researches has been done on chewaka areas farm household food security status that could be taken as evidence for researchers as a benchmark.

2.5. Conceptual framework of the study

Adoption of technologies is the outcome of several interactions of farmers' internal and external contexts. Households' characteristics, socioeconomic, institutional factors and farmers' perception of the technology's attributes are the main determinants on a decision to continuously utilizing a given technology.

As stated in Dehnenet *et al.*, (2014) age of house hold head and off-farm income activates negatively and have impact on adaption of improved technology. Unlike age of house hold head and off-farm income activates family size, farming experience, availability of extension on crop production, training and accessibility of credit has positive effect on adoption of technology. farmers training in using improved rice technology has positive and significant relationship also education status of the house hold member , experience of rice farming and participation of farmers in cooperative ,research centers and other social institution have positive relation with the adoption of improved technology (Quddus , 2016).

Different studies come up with different conceptual frame works but in this study there were some factors that affect adoption of improved rice technology in order to achieve the end result which is food security so those factors were inter linked below as their influence in household adoption of improved rice variety and food security. Farm income may have two sources it might be sale of crop or sale of livestock, household who sell their crop or livestock had a cash on their hand so they use this cash in order to buy seed and agro inputs. Off-farm income opportunities have been widely documented as an important strategy for overcoming credit constraints faced by the rural households in many developing countries including Ethiopia (e.g., De Janvry and Sadoulet, 2001; Iiyama *et al.*, 2007; Barrett *et al.*, 2001; Reardon *et al.*, 2007). Also that off-farm income for smallholder farmers increases the intensity of adoption of improved technologies, translating into increased productivity.

Other component is that Perception on improved variety in test, yield colour and disease resistance have a great impact on household adoption of improved variety this is because of if farmers get more value from the improved variety. As compared with the local one their willingness to adopt the new one will have positive impact. Physical factors such as distance to the nearest market, road also influence the adoption of improved rice variety on the household in a such a way that, if a farmer had a market close to his home he is able to supply fresh and timely bounded product so

the distance to the market decide the acceptance of farmers product and affect the customers number farmer had which are the same for access of infrastructures such as road which influence the quality of the products in case that if there was no access to road farm product my perishable due to long time passage in road .

Credit can facilitate farm households to purchase the needed agricultural inputs and enhance their capacity to effect long-term investment in their farms and also access to extension service had a positive impact on adoption of new technology. So that in this conceptual frame work the inter relationship between institutional, demographic, physical and perception of farmers on improved variety and farm supply was indicated in cross sectional line in order to adopt improved rice variety which's end result was household who has access to sufficient, safe and nutritious food.

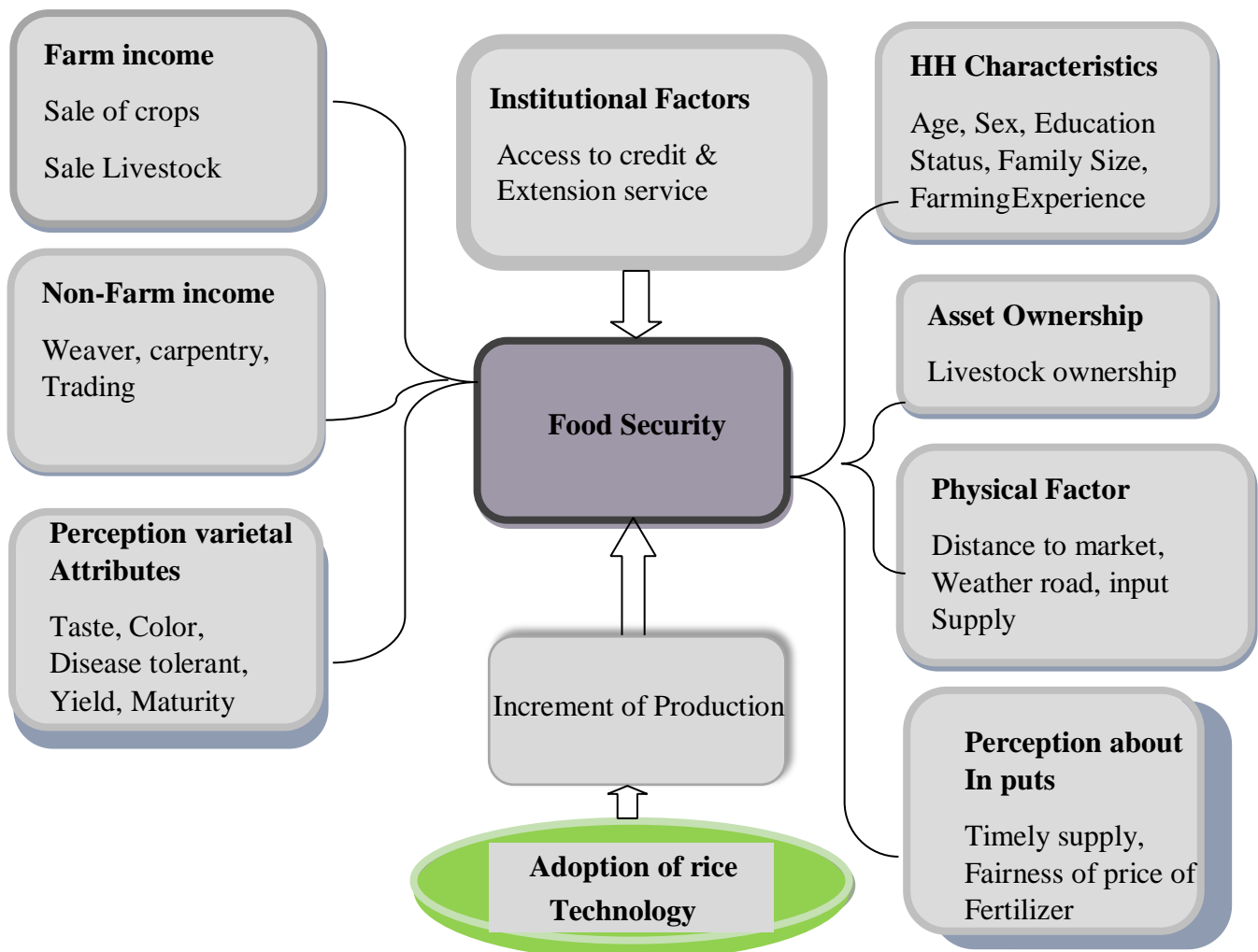


Figure 2: Sources adapted and modified from literatures by researcher

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND THE METHODS

3.1. Description of the study area

3.1.1. Location and physical features

This survey study was conducted in Chewaka *Woreda* of Buno Badale *Zone* of Oromia National Regional State. Chewaka is located at a distance of 552 km away from Capital city of the country (Capital of Oromia regional state Addis Ababa/ Finfine) and 72 km far from Beddele town. It is situated between latitude of 36° 06' E longitude and 8° 98' N latitude. The district shares boundaries with East East Wollega *Zone*, in West of Meko district, in the south direction Dabo Hanna district and in the north direction it is bordered by west Wollega *Zone*. The altitude of the *woreda* ranges from 900-1800 m.a.s.l. and the wide range of the area has gentle slope and sloppy at the border. The most common and dominating soil type is vertisols. The annual temperature varies between 24 °C to 38 °C. The mean annual rainfall ranges from 1000-2200 mm with an average of about 1125 mm and it is unimodal in nature. A small rain occurs between March and April, while the main rainy season occurs between July and September. The *woreda* has a total of 28 *kebeles*. Of the total *kebeles*, 26 belong to rural *kebeles* and 2 urban *kebeles* (CSA, 2017).

3.1.2. Population and area coverage

The total population of the *woreda* is estimated at 73,159 of which 38,703 are males and 34,456 are females. Of the total population, 71,574 are rural households of which 37,861 are males and 33,714 are females. The estimated average family size was 6.97 persons per household. Average family size of the study *woreda* was larger compared to that of the region (5 persons per household). The population density of the study area is 98 persons per km² (*Woreda* BoFED report, 2017).

The total land area of the *woreda* is 57,300 hectares. The pattern of land use indicates that 27,322.9ha (12.05 percent), 2676.9 ha (13.94 percent), 18143ha (6.33 percent), 583.9ha (7.74 percent), 1632.8 ha (1.33 percent), 4476.4 (0.63 percent) of the total area were used for Forest and shrubs, grazing land, cultivation, coffee area, chat area and others, respectively (*Woreda* BoFED report, 2017).

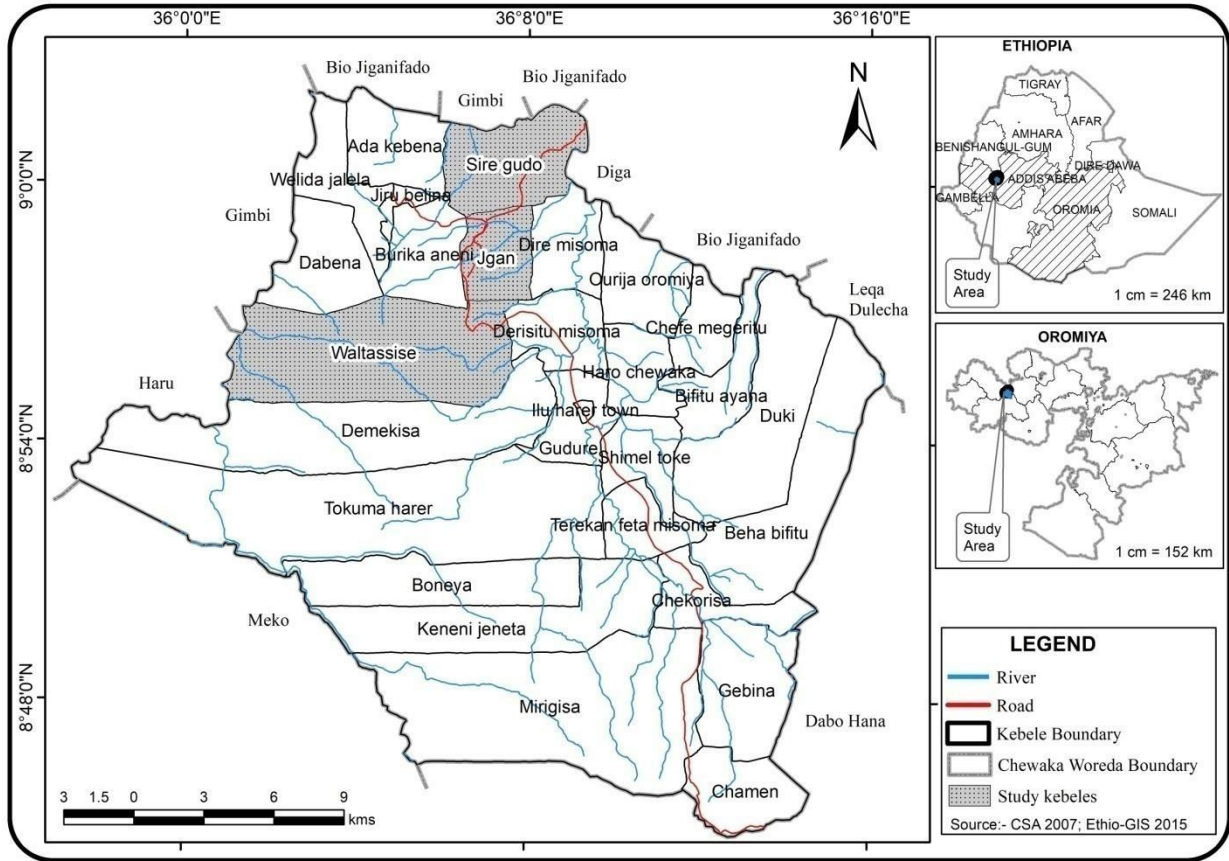


Figure 3: Map of the study area

3.1.3. Agriculture

Agriculture is the economic base of the zone. Agriculture is mainly rain-fed and is characterized by low productivity. The majority of the residents depend on agriculture for their livelihood. The farmers are using traditional technologies and with limited / no accesses to agricultural inputs. Moreover, the sector in the zone is characterized by low-level use of farm inputs, traditional farm practice, and other related problems. Farmers believe that the soils are reasonably fertile, but the major problem which makes the soils to yield low is shortage of rainfall. Otherwise, farmers believe that what they get during good rains is reasonably good. Use of commercial fertilizer is not common in the area.

The district is characterized by mixed farming system. In this farming system both crop and livestock production is undertaken side by side. Sorghum, maize, rice, sesame, haricot bean, finger millet and groundnut are the main crops grown in this production system. The area under these crops, other than sorghum is very low (Table 1). Among this major crops grown rice, sesame,

haricot bean and ground nut are the major cash crop. Rice mainly produced both for home consumption and the market purpose. In addition to food crops chat is also grown in the area. Farmers are used to growing chat in their backyards and also in the farmlands. Chewing chat is a very common practice due to that majority of the obtained agricultural information from others farmers.

Livestock is one of the important resources of farm families. It provides traction and manure to crop production. In Chewaka *woreda*, livestock are means of production and sources of income for farmers. Data from Chewaka *woreda* Office of Agriculture indicates that livestock population in the area was estimated to be 35766 cattle, 48351 goats, and 6816 sheep, 7 horses, 2201 donkey, 56284 poultry and 3858 beehives. Of the total 22, 1715 hectares of cultivable land 18,143 hectares of land was covered by crops in 2017/18 crop year. Of the cultivated land, sorghum covers the largest area covering about 5494 hectares followed by maize and Soybean crops (Chewaka BoFED, 2017).

Table 1: Type of crop grown in chewaka

Type of crop	Area in (hectare)	Production in quintal
1 Sorghum	5,494	219,760
2 Maize	3,592	215,520
3 Rice	2,524	138,820
4 Soybean	4,229	105,725
5 Haricot bean	230	5,060
6 Sesame	2,072	14,504
7 Groundnut	73	1,533

Source: Chewaka BOFED, 2017

3.2. Research design

This research was carried out by using cross-sectional survey design that take an account in adopter and non-adopter in which the dependent group is (technology adopter) and control group (non - adopter) house hold was analyzed in this those who use the technology for more two years or above considered as adopter and those who was less is considered as non-adopter also as we know technology is full of packages so this study focused on use of improved variety of rice for

house hold heads to achieve objectives production data was used for the quantitative data in order to get the expected result

3.2.1. Sampling procedure

Multi-stage sampling procedure was employed to select sampled farm household. In the first stage in the sampling procedure, Chewaka district from Buno Bedele Zone was selected based on its rice production potential and targeted district of project which was working on rice technologies dissemination for more than five years in the area. At the second stage, three *kebeles* were randomly selected from district among rice potential growers *Kebeles*. Before the selection of *kebeles*, lists of *kebeles* in the district was obtained from the Bureau of agriculture.

3.3. Data types, sources and method of data collection

3.3.1. Types and source of data

For this study both quantitative and qualitative data from primary and secondary sources was gathered and analyzed. Primary data was collected by means of household survey using a set of pre-tested questionnaires and checklist. Accordingly, enumerators who have better knowledge of the farming system and good command of the local languages (both Afan Oromo and Amharic) in the study area was used. The questionnaire was developed in English Language, which was then be posed to the respondents in the language the producers speak and understand. Prior to preparing the questionnaire for interview schedule, key informant rating and four focus group discussions comprising of 6-9 farmers drawn from the selected *kebele* was made so as to identify key issues that would be good inputs in questionnaire development.

In addition to primary data, secondary data were also collected for this study. Secondary data from unpublished records and reports was obtained mainly from the following institutions. Buno Badele zone Department of Agriculture, Chewaka *Woreda* Agriculture Office, Department of Planning and Economic Development, Disaster Prevention and Preparedness Commission (DPPC) and NGOs working in the *Woreda*. Literatures related to rice production and food security issues from libraries and other institutions were also reviewed.

3.3.2. Methods of data collection and tools

Both the conventional household survey and participatory rural appraisal survey was employed during the data collection process of this study. For this study, the conventional household surveys were the main method used to collect quantitative information. A carefully designed questionnaire consisting of interrelated questions was employed and administered by semi trained enumerators. Sample household heads was asked about the unit of analysis from whom quantitative information collected. Enumerators employed to conduct the survey under the close supervision of the researcher.

Household survey was conducted by using structured questioner by enumerators. Since the quality of the interviewer was one of the most important factors in conducting a successful survey, interviewers were selected based on five important characteristics. These includes: (a) motivation to work hard and honestly, (b) ability to fill the questionnaire correctly, (c) ability to communicate with the farmers in the local language, (d) knowledge of local farming practices and, (e) respect for farmers and rural people. These criteria was considered in the interview for recruitment and in the training. Prior to the launching of the survey, enumerators was briefed about the survey and familiarized with the questionnaire.

The qualitative assessment added useful in depth and perspectives in understanding issues that could not be obtained from questionnaire method. Qualitative data collection methods was used to obtain insights, thoughts and attitudes of peasants concerning food security and their perceptions of the rice technology in the study area.

Focus group discussion and key informant interview this was carried out with maximum participant such as rice producer house hold, agriculture extensions, elders, woman – headed household head and others included below with farm households was one of qualitative data collection method in this survey Study. Each focus group was comprised within the range of 10 to 15 individuals who are found in the same village in the study area. Individuals who was considered knowledgeable and rich in experiences about rice production activities and socioeconomic condition of the community in the study area will be identified and interviewed individually. The key informants interviewed will be also include including, local religious leaders, development agents, *Woreda* and *Kebele* officials and zonal experts.

3.4. Sample Size Determination

There are several approaches to determine the sample size. These include using a census for Small populations, imitating a sample size of similar studies, using published tables, and applying formulas to calculate a sample size. To obtain a representative sample size, for cross-sectional household survey the study employed the sample size determination formula given by Kothari (2004).

$$n = \frac{Z^2 Pq}{e^2}$$

Where n is the sample size needed, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from statistical Table which contains the area under the normal curve of 90% confidence level.

In the determination of sample size where there is large population, but we do not know the variability in the proportion about the use of adoption rate of technology, in rice production, p = 0.5 is considered as suggested by Kothari (2004). Based on this, a total of households were selected for the study from the three selected *kebleas* and assuming a 90 percent confidence level and ± 10 percent precision.

Table 2: Sampled PAs and number of households selected from each sampled PAs

Study district	Study Kebele	Total households in each kebele	Percent %	Households Sample will be selected from each Kebele
Chewaka	Jagan	465	33	62
	Waltasise	429	32	60
	Sire Gudo	445	33	66

Source: secondary data from respective kebeles of district

3.5. Measurements and definitions of variable

3.5.1. Dependent variables

The dependent variables dealt with had two categories, dichotomous and continuous nature. The dependent variable in the first stage (tobit model) were dichotomous variables depending on the farmers' decision to adopt improved rice technology or not. It was represented by 1 (one) for those who adopted improved rice technologies and zero (0), otherwise. However, in the second stage (truncated model) we have a continuous value which would be the intensity of use of the technology. Intensity of use refers to the level of adoption (how many hectares of land was allocated for improved rice variety (chewaka) to the total area under the local rice variety. Farmers who grow chewaka variety with its either full or part of packages, raw planting, recommended fertilizer rate were regarded as adopters, but those who do not use the improved variety with its package are regarded as non-adopters. As the variables explaining adoption might also explain level of adoption, the set of independent variables are used in both stages (Probit and truncated models).

3.5.2. Outcome variable

Adoption and productivity

Agricultural productivity is the measurement of the quantity of agricultural output produced for a given quantity of input or a set of inputs. There are different ways of defining and measuring productivity. For instances, the amount of output per unit of input (such as tons of rice per acre of land), or an index of numerous outputs divided by an index of numerous inputs (Wiebe, 2003). The quantities of output relative to the quantity of inputs are the conventional measures of productivity. If output increases at the same rate as inputs, then productivity is unchanged. On the other hand if the output growth rate exceeds the growth rate in the use of inputs, then productivity is positive. Factors, that contributes for productivity the role of human capital, research and technological development or technology transfer, public investment in agricultural research, extension services and infrastructural development, sustainable natural resources management, policy reform and political stability etc.

So it assumed that Technological improvement is one of the key sources of productivity growth in which if there were increase in technology there were increase in food security. Agricultural productivity growth was positively correlated with lower food prices, better nutritional intake and increased capital flows also there were positive relation between different agricultural productivity measures and average real GDP growth Increased agricultural productivity growth may contribute in overall economic growth by improving the availability of food which is the first and foremost step of food security.

Food Security

Food security is that it refers to the ability of individuals to obtain sufficient food on a day-to-day basis. Internationally food security is defined as the ability of people to secure adequate food. HFBM is a method use for food security in terms of kilo calorie. Food security has three dimensions namely food availability, food access and food use. Food availability in the definition implies that a country must have sufficient quantities of food available on a consistent basis at both national and household level. Food access implies the ability of a nation and its households to acquire sufficient food on a sustainable basis. Though if there were adoption of new technology there is a food security in the household.

3.5.3. Independent variable

Adoption literatures provide a number of factors that may influence the adoption of agricultural technologies. Generally, farmers' decision to use improved agricultural technologies and the intensity of the use in a given period of time are hypothesized to be influenced by a combined effect of various factors such as household characteristics, socioeconomic and physical environments in which farmers operate. The explanatory variables that will be included in the empirical models are selected following the literature spelled by Federet *al.* (1982). The explanatory variables included in this study are age of the household head, sex of the household head, education level, farming experience, training on finger millet production, livestock ownership (TLU), number of oxen owned, access to credit, family size, farm size, distance to all weather road, distance to farmers' training center (FTC), perception of the farmers on characteristics of the varieties, extension contact and dependency ratio .

Age of household head: Age is a continuous measured in years. The effect of age on rice technology adoption decisions is expected to be positive (Sisay, 2016). Older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology. Thus, for this study, it is hypothesized that age of the farmer positively influences the decision to adopt and use intensity of improved rice technologies.

Household sex: Is dummy variable representing the sex of the head of the household; where, female = 1, male = 0. Previous research in Africa has documented women's lesser access to and control over critical economic resources, especially land, cash, labor and information (Kaliba *et al.*, 2000; Quisumbing *et al.*, 1995). Thus it does not appear that gender per se heavily affects adoption patterns. Rather the inherent resource inequities in ownership and control of productive resources between men and women play a big role. For rice technology adoption involving the use of financial resources (mineral fertilizer and seed purchase) and additional labor (row planting and fertilizer application), it is hypothesized that male headed households are more likely to adopt and allocate more land than female-headed households.

Adult equivalent family size: It refers to the total number of household members within the given household. It is believed that labor constraint affects household's ability and willingness to adopt and use a new technology (Feder *et al.*, 1985). The larger is the family size, the more labor is expected within that household. Accordingly, it is hypothesized for this study that it positively affects household's rice technology adoption.

Education level of the household: It is a continuous variable measured in number of years in schooling. More educated farmers may be more aware of the benefits of modern technologies and may have a greater ability to learn new information hence easily adopt new technologies. Education is expected to be positively and significantly influencing adoption of new technologies Afework and Lemma, 2015). Increased year of schooling, thus, is hypothesized to have a positive effect on the decision to adopt rice technologies.

Frequency of contact with extension agents: It is a continuous variable, measured in the number of times a household makes contact with extension agents. Contact between the extension agent and the farmers is hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new crop technologies. According to Yemane, (2014) contact with extension

agents has positively influenced the adoption of improved upland rice varieties. Similar study of Hassen *et al.*, (2012) indicated that, more contacts with extension agents will increase farmers' adoption of technologies. It is, thus, hypothesized that increased frequency of contact with extension workers will increase a farmer's likelihood of adopting new technologies.

Farm size: It is a continuous variable measured in hectares. Farm size is an indicator of wealth and social status and influence within a community. This means that farmers who have relatively large farm size will be more initiated to adopt technologies. And the reverse is true for small size farmers. Moreover, farmers operating larger farms can afford to devote part of their fields to try out the improved technology (Rahm and Huffman, 1984). According to recent studies land holding size returned a positive and significant relationship with adoption of new technology. It is, thus, hypothesized that large farm size increases the probability of the adoption of all the studied technologies.

Farmers' perception of the technologies: Is a dummy variable rated as yes/no to a series of questions regarding perception of the farmers about the technologies. Adesina and Baidu (1995), demonstrate the importance of farmers' perceptions of technology characteristics on adoption. Farmers' positive attitude of a given practice is hypothesized to hasten the adoption of the new practice.

Access to credit: It is a dummy variable that takes a value of one (1) if households have access to credit and zero (0), otherwise. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. The credit availability positively affects the adoption of improved technologies (Tiamiyu *et al.*, 2014; Leake and Adam, 2015). Therefore, it is expected that access to credit will increase the probability of adopting rice technologies.

Livestock holding: It is a continuous variable measured in TLU. A household with large livestock holding can obtain more cash income from the sales of animal products. This income in turn helps smallholder farmers to purchase farm inputs. Leake and Adam (2015), reported that being owner of more livestock increases the level of adoption of improved agricultural technology. Ownership of cattle is assumed to increase income through sales of the cattle or their byproducts. Therefore, livestock ownership is hypothesized to be positively related to the adoption of rice technologies.

Distance to the market: It is a continuous variable measured in walking minutes. Living far from the major market can reduce the expected profitability of a new technology and create a barrier associated with limited price information about distant marketing outlets and increased transaction costs (Abdullah and Huffman, 2005). Distance simply refers to physical dimension without any due attention to the quality aspects of the road. The hypothesis here is that, living at a greater distance from the major market retards speed of adoption of the practices. Better access to the market can influence the use of output and input markets, and the availability of information. It is expected that farmers living near to the market would easily access market for their farm produce hence readily adopt new technology. Therefore, it is hypothesized that market distance was inversely related to adoption of rice technologies.

Timely availability of fertilizer: is dummy variable represented as 1 if fertilizer is available on time, and 0, otherwise. Availability of fertilizer on time had positively and significantly influences the probability of adoption of improved agricultural technology (Chilot *et al.*, 1996; Yishak and Punjabi, 2011).

Income from participation in off-farm activities: It is treated as a continuous variable measured in the amount of money a given household generates from participation in off-farm activities. Off-farm income may compensate for missing and imperfect credit markets by providing ready cash for input purchases and could also be used to spread the risk of using improved technologies (Mathenge and Tschirley, 2007). The households engaged in off-farm activities are better endowed with additional income to purchase inputs. The study by Olalekan and Simeon (2015) indicated that participation in off-farm income activities has a positive influence on the adoption of new technology. Therefore, it is hypothesized that the availability of off-farm income positively influences adoption of rice technologies.

Farm experience: It is a continuous variable measured in years of rice production. It is expected that farmers who have adequate experience in rice production and its rate are more likely to adopt the technologies than those who lack it. Afework and Lemma (2015) indicated that farm experience affects adoption of improved varieties. It is, thus, hypothesized that farm experience will positively affect adoption and intensity of use of rice technologies.

Training acquisition: It is dummy variable measured as 1 if farmers get specific training on the technology (in this case improved rice production and fertilizer usage) and, 0 otherwise. Farmers

may obtain information from different source and may learn also from DAs through extension programs. However unless they can obtain required skill through training they may face some difficulties to understand and apply improved agricultural technologies. So those farmers who got training on improved agricultural technology are more willing than those who didn't get training. The hypothesis with this study, thus, is that farmers who did get training on rice production would adopt rice technologies than their counter parts.

Cooperative membership: Household head's membership to farmer cooperatives may facilitate information sharing is used as proxy for assessing the role of technology adoption practice of farmer. Association such as farmer cooperatives facilitates information provision related to price, marketing and provision of credit services. A farmer who is member of farmer cooperative is more likely to adopt than others.

Off/non-farm income: It is annual income in Birr from off/non-farm economic activities through external labor supply, rentals of ox power, pack animals and land, handicrafts, petty trade, and so on (Hussein, 2007; Hassen et al., 2011). The more off/non-farm income the farmer generates, the higher he/she resolves his/her financial constraints, the faster to adopt newly released rice technology and the better to adopt recommend agronomic practices in maize farming. It was therefore hypothesized that off/non-farm income has a positive influence on the status, intensity, speed of technology adoption and decision to adopt recommended agronomic practices in rice.

Economically active labor: Availability and amount of family labor plays a vital role in determining adoption and intensity of use of agricultural technologies. The existence of active work force in rural households usually encourages them to show interest in trying some agricultural technologies. Off course, the influence of labor availability on adoption depends on the characteristics of the technology to be adopted.

Farmer perception on technology: Farmers' Perception to technology characteristics were very important explanatory variables that are usually omitted in most of agricultural technology adoption studies. Few studies has been able to reveal the importance of such variables in explaining adoption of technologies such as a study of farmers' perception and adoption of Modern Sorghum and Rice varieties in Burkinafaso and New Guinea by Adesina and BaiduForson (1995).

Table 3: Variables, their measurement and expected signs

Definition Variables	Unit of Measurement of Variables	Expected Signs
Adoption of improved Rice technology	Dummy(Yes/no)	
Area under improved rice	Continuous (hectare)	
Independent Variables		
Age of household	Years	Positive (+)
Sex of household head	Male/female	Negative (-)
Education of household head	Formal school in years	Positive (+)
Income from off-farm activities	Amount in Ethiopian birr	Positive (+)
Farming experience of HH	Year	Positive (+)
Labor force in man equivalent	Number (ME)	Positive (+)
Total farm size	Cultivated in ha	Positive (+)
Farm production	Quintal	Positive (+)
Improved seed	(Yes/no)	Positive (+)
Fertilizer	(Yes/no)	Positive (+)
Contact development agent	(Yes/no)	Positive (+)
Family size	Number	Positive (+)
Credit access	Yes/No	Positive (+)
Membership of corporative	Yes/No	Positive
Distance to the nearest market	Continues	Negative
Rice growing experience years	Discrete	Positive
Economically active labor	Discrete	Negative
Farmer perception on technology	Superior , medium and not superior	Positive

3.6. Method of data analysis

The quantitative data will be processed and analyzed using the Statistical Package for Social Sciences (SPSS Version12). Descriptive statistics such as mean, standard deviation (SD), frequencies, and percentages will be used to have a clear picture of the characteristics of sample units. Chi-square analysis will be applied to the discrete variables while t-test will be applied to the continuous variables. In addition household food balance model will be used to analyze food security status of households. Finally different regression model will be employed analyze the rate and intensity of adoption of rice production technologies, and to identify variables significantly affecting household food security. Following the convention, VIF (Variance inflation factor) for association among the metric explanatory variables and contingency coefficients for categorical variables will be used as tests of multi-collinearity

3.6.1. Methods of analysis for adoption

Descriptive analysis

The quantitative data was processed and analyzed using the Statistical Package for Social Sciences (SPSS Version12). Descriptive statistics such as mean, standard deviation (SD), frequencies, and percentages will be used to have a clear picture of the characteristics of sample units. Chi-square analysis will be applied to the discrete variables while t-test will be applied to the continuous variables.

Econometrics analysis

Intensity of adoption

Tobit econometric model were applied to analyze the trends and intensity of households' adoption in rice technology respectively. Probit model is estimating the probability of adoption as a function of other explanatory variables. The interest of Tobit model is finding out not only the probability of adoption but it can also indicate the intensity of adopters in rice technology. It describe the relationship between a non-negative dependent variable Y_i and an independent variable (or) X_i . Tobit econometric model was applied for analyzing explanatory variables of adoption and intensity of adoption as shown at equation (1).

$$Y_i^* = \beta X_i + u_i \quad i = 1, 2, \dots, n$$

$$Y_i = Y_i^* \text{ if } Y_i^* > 0$$

$$Y_i = 0 \text{ if } Y_i^* \leq 0 \text{ ----- (1)}$$

Where, Y_i is the observed dependent variable, in this case adoption of rice technology. Y_i^* is the latent variable which is not observable. X_i is vector of factors determining adoption rice technology and its intensity. β is vector of unknown parameters to be estimated and u_i is residual that are independently and normally distributed with mean zero and a constant variance. The model parameters are estimated by maximizing the Tobit likelihood function of the following form:

$$L = \prod_{i: Y_i > 0} f(Y_i - \beta X_i) \prod_{i: Y_i = 0} F(-\beta X_i) \text{ ----- (2)}$$

Where f and F are respectively, the density and cumulative distribution functions of Y_i^* ,

Means the product over those i for which $Y_i > 0$ and means the product over those i for

Which.

Thus, a change in X_i (exogenous variables) has two effects. It affects the conditional mean of Y_i^* in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. The software STATA was used to compute the Tobit econometric model. Many authors proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects. Thus, a change in X_i (explanatory variables) has two effects.

1. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(Y_i)}{\partial X_i} = F(z) \beta_i \sigma \text{ ----- (3)}$$

Where z is denoted by $\beta X_i / \sigma$, Maddala [8].

2. The change in probability of adoption rice technology, as independent variable X_i changes is:

$$\frac{\partial f(z)}{\partial X_i} = f(z) \beta_i \sigma \text{ ----- (4)}$$

3. The change in intensity of adoption with respect to the change in an explanatory variable among adopters is:

$$\frac{\partial E(y_i^i > 0)}{\partial X_i} = \beta_i = \left[1 - z \frac{f(z)}{F(z)} \right]^2 - \frac{f(z)^2}{F(z)^3} \dots \dots \dots (5)$$

Where, F(z) is the cumulative normal distribution of Z, f(z) is the value of the derivative of the normal curve at a given point i.e. unit normal density, Z is the z-score for the area under normal curve, β is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Analysis of and trends of rice production and its food value

For achieving this objectives an assessment on share of rice farm size, share of rice in house hold food consumption, share of rice in house hold income will be assessed by using different method of assessment which will be decided based on the data obtained .

Food security analysis

Food security at the household level is measured by direct survey of income, expenditure, and consumption and comparing it with the minimum subsistence requirement. In this regard, income and expenses are used to compute the status of food security. The minimum level of income, which is required per adult equivalent, was calculated on the basis of amount of food required by an adult person. The government of Ethiopia has set the minimum acceptable weighted average food requirement per person per day at 2100 kilo calorie (FDRE, 1996; cited in Kifle, 1999), which is estimated to be 225 kg of food (grain equivalent) per person per year. Consequently, a threshold level is set by computing the value of this amount of cereal by the existing local market price of grain. Thus, those households beyond this thresholds level was deemed to be food secured otherwise not food secured.

Household food balance

HFBM is employed to compute the net quantity of per capita food. The net available food per household, as reported from household recall, is converted into dietary energy equivalent using EHNRI/FAO (1998)'s Food Composition Table for Use in case of Ethiopia. Then, the medically recommended level of calorie per adult equivalent (2100kcal/day/person for Ethiopia) is used as a cut-off point for food insecure and food secure households or individuals. The following simple equation of HFBM is modified and used by Messay (2011) for household food security analysis is:

$$NGA = (GP + GB + FA + GG + CC + MP + DP) - (HL + GU + GS + GV)$$

Where,

NGA = Net grain available (quintal/household/year)

GP = Total grain production (quintal/household/year)

GB = Total grain bought (quintal/household/year)

FA = Quantity of food aid obtained (quintal/household/year)

GG = Total grain obtained through gift or remittance (quintal/household/year)

MP = Meat, meat based products and poultry (kilogram/household/year)

DP = Dairy and dairy based products ((kilogram/household/year)

HL = Post harvest losses due to grain pests, disasters, thievery, etc (quintal/household/year)

GU = Quantity of grain reserved for seed (quintal/household/year)

GS = Amount of grain sold (quintal/household/year)

GV = Grain given to others within a year (quintal/household/year).

Hence the probability of household in food secured if the daily calorie intake greater than 2100kcal per person per/day and 0 if house hold food in secured when daily calorie intake is less than 2100kcal per person per /day (FAO, 1998 cited by Messay, 2012)

$$1 \text{ if } y < 2100$$

$Y(x) = []$ where $y(x)$ food security status of households 0 if $y > 2100$

After this other model employed in the research were ordered logit. Which is used to estimate the linkage between the food security and adoption of technology. The linkage between the household food security and adoption this model were employed. In this variables has four outcomes hence the ordered logit categories dependent variables in to four 1, 2, 3 and four there representation were as 1. Food secured, 2 for mild, 3 moderate and 4 food insecure according to (Stata Corp, 2013) the model whereas follow

The probability of a given observation for ordered logit were

$$y(x) = \begin{matrix} 1 & \text{secured} \\ 2 & \text{mild} \\ 3 & \text{moderate} \\ 4 & \text{insecured} \end{matrix}$$

Where $y(x)$ = status of food security condition of farm household

Logistic Model

The model was applied to identifying factors affecting food security status of household. A logistic model is specified to identify the determinants of food insecurity and to assess their relative importance in determining the probability of being in a food insecure situation at household level. The analysis of the logistic regression model was shown that changing an independent variable alters the probability that a given individual becomes food secure, and will help to predict the probability of achieving food security

Following Gujarati (1995), the functional form of logit model is specified as follows For ease of exposition, we write (1) as:-

$$P_i = \frac{1}{1 + e^{-z_i}} \tag{1}$$

The probability that a given household is food insecure is expressed by (2) while, the probability for not food insecure is:-

$$1 - P_i = \frac{1}{1 + e^{z_i}} \tag{2}$$

Therefore we can write:-

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{z_i}}{1 + e^{-z_i}} \tag{3}$$

Now $(P_i/1-P_i)$ is simply the odds ratio in favor of food insecurity. The ratio of the probability that a household will be food insecure to the probability of that it will not be food insecure. Finally, taking the natural log of equation (4) we obtain:-

$$Li = \ln \left[\frac{P_i}{1 - P_i} \right] = Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n \tag{4}$$

Where P_i = is a probability of being food insecure ranges from 0 to 1

Z_i = is a function of n explanatory variables (x) which is also expressed as:-

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n \tag{5}$$

s0 is an intercept

s1, s2 ----- sn are slopes of the equation in the model

Li = is log of the odds ratio, which is not only linear in Xi but also linear in the parameters.

Xi = is vector of relevant household characteristics

If the disturbance term (Ui) is introduced, the logit model becomes

The logit model cannot be estimated by the usual ordinary least square method because to apply OLS we must know the value of the dependent variable $\ln(P_i / 1 - P_i)$, which obviously not known and more over the methods of OLS doesn't make any assumptions about the probabilistic nature of the disturbance term. If there is data on individual observations the method of maximum likelihood can be used to estimate the coefficients of the equation (Gujarati, 1999).

It needs to be clarified that prior to the estimation of the logistic regression model, the explanatory variables were checked for the existence of multi co-linearity. In this study among the other methods Variance Inflation Factor (VIF) was used to measure the degree of linear relationships among the continuous explanatory variables. Where each continuous explanatory variable is regressed on all the other continuous explanatory variables and coefficient of determination for each axillary or subsidiary regression will be computed.

Following Gujarati (1995), VIF is defined as:

$$VIF_j = \frac{1}{1 - R_j^2} \quad (1)$$

Where:

Xj = the jth quantitative explanatory variable regressed on the other quantitative explanatory variables.

R²_j = the coefficient of determination when the variable Xj regressed on the remaining explanatory variables.

As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear and it can be concluded that multi-collinearity is a problem (Gujarati, 1995).

It is also evident that there might be interaction among qualitative variables, which could lead to the problem of multi-collinearity. To detect this problem, contingency coefficients were computed for each pair of qualitative variables.

3.7. Ethical consideration

Permission was required from the graduate school of AAU and approval to carry out the research was granted. Ethical clearance was obtained from chawaka district. The questionnaires was administered to the respondents upon obtaining an informed written or thumb print consent. Before consent was obtained, the researcher and the research assistants were explained the purpose of the study and respondents were assured of confidentiality of the information they give. To ensure privacy, names and other means of identity was not been used during the data collection. The researcher was ensure that all information obtained will be kept in strict confidence and will be used only for the purpose of the study.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter includes the major finding of the research and deliberates it in contrast with result of other studies. Under this study both descriptive and econometric methods were used to analyze the primary data. Descriptive statistics were employed to describe the general demographic, socio-economic and institutional characteristics of rice producer in the study area. Econometric analysis was also used to identify factors affecting adoption and intensity of adoption of improved rice varieties in the study areas.

4.1. Descriptive results

4.1.1. Demographic characteristics households for adoption

The sample size handled during the survey was 178 Out of the total interviewed rice producers were from Chewaka district of the selected three kabeles 33% from waitesis ,32% from dire misoma and 35% were from jagan Among the sample respondents from chewaka district, (90.06%) were male headed and the remaining (3.93%) were female headed rice producers, respectively. The chi-square test of sex distribution between the adopters and non-adopters was found to be insignificant. Out of the total respondents, 96.31%, 2.8 % and 0.56 % were married, single and widowed respectively. The chi-square test of marital status between the adopters and non-adopters was found to be insignificant (table 4).

Table 4: Demographic characteristics households for adoption

Variable		Adopters (N=160)		Non-adopters (N=18)		χ^2 -test	Total (N=178)	
		No	%	No	%		No	(%)
Sex	Male	154	90.06	17	9.94	0.7	171	96.06
	Female	6	3.71	1	5.56		7	3.93
Marital status	Married	154	89.53	18	10.47	0.705	172	96.31
	Single	5	3.13	0	0		5	2.8
	Widowed	1	0.63	0	0		1	0.56

Source: own survey data, 2019

The average age of the adopters was 34.8 years and while it is about 44.33 years for nonadopters. The t-test of age between adopters and non-adopters was found to be significant at 10%. That means there is statistical mean difference between adopters and non-adopters in terms of age in which younger household heads are more flexible and hence likely to adopt new technologies the more the house hold young the more casual to adopt a technology (Table 5).

Table 5: mean age of adopters and non-adopters

Variables	Adopter (N=160)		Non-adopters (N=18)		t-test
	mean	Std	Mean	Std	
Age	34.8	10.65	44.33	17.01	3.36*

Source: analyzed from own data, 2019

Socio economic characteristics

Family size is refers to the number of persons in the family and it is one of the variables that characterize farm households. The average family size of the adopters was 5.0 people and while 6.6 persons is for non-adopters. The t-test of family size between adopters and non-adopters was found to be significant at 5% (Table 6).

Experience in rice production is taken to be the number of years that an individual was continuously engaged rice farming. The average years of rice production experience for the adopters was about 4.00 years and 3.55 years for non-adopters with standard deviation of 2.02 and 4.68 respectively. A producer with better experience in rice production is expected to adopt new technologies than less experienced. The t-test of farm experience between adopters and non-adopters was insignificant (Table6).

Education can influence productivity of producers and adoption of newly introduced technologies and innovations. Hence, literate producers are expected to be in a better position to get and use information which contributes to improve their rice production practices. According to the survey results, on average adopters have about 64.% of house hold head with formal education and about 35.6 % of house hold head who was not able to read and write , while non- adopters have 27.7% of formal education and 72.2% of the house hold who was not able to read and write . The t-test result indicates that education level of household was found to be significant between adopters and non-adopters at 5% level of significance. That means adopters have higher level of

education compared to non-adopters and it is found that there was a statically mean difference between adopter and non-adopter. (Table 6)

Table 6: chi-square result of age and adoption

Variable	Adopters (N=160)		Non-adopters (N=18)		χ^2 -test
	No	%	No	%	
Not read or write	57	35.6	13	72.2	0.003**
Formal	103	64.4	5	27.7	

Source: analyzed from own data, 2019

Farm animals have an important role in rural economy. They are source of draught power, food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. The districts where known by livestock production as major occupation. Livestock holding size is also one of the indicators of wealth status of the households in the study areas. Livestock is kept both for generating income and traction power. As it confirmed in many studies, farmers who have better livestock ownership status are likely to adopt improved agricultural technologies because livestock can provide cash through sales of products which enables farmers to purchase different agricultural inputs like seeds and used as traction power.

The livestock species found in the study areas are cows, oxen, bulls, heifers, calves, sheep, goat, donkey, mule and poultry. To help the standardization of the analysis, the livestock number was converted to tropical livestock unit (TLU).The conversion factors used were based on Storck *et al.*, (1991) .The average livestock ownership of adopters was and TLU for the non-adopters. The t-test of livestock holding between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of livestock holding (Table7).

The average total land holding, total cultivable land and land allocated for improved for adopters 1.7 is, 1.5 and 0.3 hectares respectively while it is, 1.5, 1.57 and 0 hectares for non-adopters. The t-test of total land holding and total cultivable land between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of total land holding and total cultivable land but the t-test of land allocated for

improved rice between adopters and non-adopters was found to be significant at 1% level of significance indicating that there is statistical mean difference between adopters and non-adopters in terms of land allocated for improved rice varieties (Table7).

Table 7: socio-economic factor and adoption

Variable	Adopter (N=160)		Non-adopters (N=18)		
	mean	Std	Mean	Std	t-test
Family size	5.0	0.15	6.6	2.8	3.1
Farm experience	3.5	2.02	3.4	4.68	-0.27
Livestock holding(TLU)	2.3	2.6	2.31	2.19	0.09
Total land holding	1.7	0.04	1.57	0.53	0.03
Total cultivated land	1.5	0.4	1.5	0.5	-0.13
Land for improved rice	0.3	0.20	0	0	7.3

Source: analyzed from own data, 2019

Frequency of extension contact refers to the number of contacts per year that the respondent made with extension agents. The effort to disseminate new agricultural technologies is within the field of communication between the change agent (extension agent) and the farmers at the grass root level. Here, the frequency of contact between the extension agent and the farmers is hypothesized to be the potential force which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new technologies. The mean extension contact for adopters is 96.12 % and non-adopters was and 3.85 % respectively. The t-test of extension contact between adopters and non-adopters is significant at 5% level of significance indicating that there is statistical mean difference between adopters and non-adopters in terms of frequency of extension contact (Table8).

Table 8: extension service and adoption

Extension contact	Adopter		Non adopter		p-value	Total	
	N	%	N	%		N	%
Yes	124	96.12	5	3.85	0.019**	129	72.5
No	36	73.47	13	26.53		49	27.52

Source: analyzed from own data, 2019

Participation in off/non-farm activities and Access to credit

Participation on off can affect the decision to adopt new technologies. This is particularly true if the adoption of the new technology would require a minimum investment in purchased inputs.

Most of the farmers interviewed reported that they didn't participate on off/non-farm because of poor infrastructure development in the area. About 12.5 % of adopters and 16.6 % non-adopters participate.

The χ^2 test of off farm participation between adopters and non-adopters was found to be insignificant. That means there is no difference between adopters and non-adopter in off farm and non-farm participation (Table 9).

Credit is an important institutional service to finance poor farmers who cannot purchase input from own savings especially at early stage of adoption. As presented in table 9, about 60.6 % and 38.7% adopters and non-adapters access credit respectively while about 27.7 % and 72.2 % does not access credit. The result of χ^2 test revealed that there is difference in access to credit between adopters and non-adopters farmers at 10% level of significance.

Table 9: perception about off-farm and credit

Variables		Adopters (N=160)		Non-adopters (N=18)		χ^2 test	Total (N=178)		
		No	%	No	%		No	%	
Off farm	Yes	20	12.5	3	16.6	0.62	23	15.07	
	No	139	86.8	15	83.3		154	84.93	
	Yes	97	60.6	5	27.7	0.007	52.74	102	
	No	62	38.7	13	72.2		47.26	102	

75 Source: source: analyzed from own data, 2019

Distance to nearest market

The time taken to travel from home to the nearest rice market place where farmers sell their product (rice), are presented in table10. Adopters and non-adopters travel on average 2.68 and 12.9 hour respectively to reach nearest market. The t-test of distance to nearest market between adopters and non-adopters is insignificant there is no static mean difference between the adopter and non-adopter

Table 10: Distance to nearestMarket

Variable	Adopter (N=48)		Non-adopter (N=98)		t-test
	Mean Value	Std	Mean	Std	
Distance to market	264	1713.8	41.7	51.92	-0.55

Source: analyzed from own data, 2019

Major crops produced

As presented in table in the study areas, rice is the dominant crop produced with mean 21.35 % quintals for adopters and 4.0 % for non-adopters and it is the basis of livelihood in the study areas. The second dominant crop produced is maize with mean of 17.7 and 15.3 % quintals for adopters and non-adopters respectively. Sorghum is the third dominant crop produced with mean of 9.3% and 8.41% quintals for adopters and non-adopters respectively. The result of t- test revealed that there is significant mean difference between adopters and non-adopters farmers in terms of amount of rice produced and amount of sorghum produced at 1% significance level for the rice producers.

Table 11: major crops produced in the area

Variables	Adopters (N=48)		Non-adopters (N=98)		p-value
	Mean	Std	Mean	Std	
Amount of maize produced	17.7	26.16	15.3	55.76	0.7
Amount of sorghum produced	9.31	6.64	8.41	4.3	0.52
Amount of rice produced	21.35	4.0	4.0	4.09	0.001**

Source: analyzed from own data, 2019

Perceptions about rice varieties attributes

In order to get insight on farmers' decisions of new technology use, looking at their perceptions about each attributes of a given technology is of paramount important. Hence, knowledge of respondent farmers' evaluative criteria as regard to technology attributes is needed. These include: yield, drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging. Three descriptions, i.e., superior, the same and inferior were used to facilitate the comparison by farmers of the recommended improved rice varieties against their local seed.

About 0, 11.93 %, 24.43%, 48.86%, 2.84%, 8.52% and 42.05 % respondents perceived that the traits yield, drought resistance, early maturity, shattering, disease resistance, and non-logging of the improved soya bean varieties are inferior to the local ones. 0, 6.88%, 4.55%, 6.25% ,39.20%, 7.95% and 9.66 % respondents perceived that the traits drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved rice varieties are the same to the local ones while About 100%, 81.25%, 71.02%, 44.89%, 57.95%, 83.52% and 51.70 % respondents perceived that yield, drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved rice varieties are superior to the local one.

Table 12: perception about improved rice variety

Attributes	Percent		
	Inferior	The same	Superior
Yield	0	0	100
Drought resistance	11.93	6.88	81.25
Early maturity	24.43	4.55	71.02
Shattering	48.86	6.25	44.89
Marketability	2.84	39.20	57.95
Disease resistance	8.52	7.95	83.52
Non-logging	42.05	9.66	51.70

Source: analyzed from own data, 2019

Source of information about improved verity

For one house hold having appropriate source of information to meet there needs can save their time and help them to get hold of relevant information. To adoption a new technology there have to be a source of information about the input they are going to use according to this survey study there were some information sources where the farmers get appropriate information about improved rice technology in order to improve their productivities, some of information sources from the house hold is listed below. As the result shows below farmers from the study area get more information from Research center 28.81%, Neighbor 21.14% and 12.43% from development agents respectively.

Table 13: source of information about IRV

Source	Number	Percent (%)	Cumulative
DA	22	12.43	13.56
Research center	44	28.81	42.37
Neighbor	38	21.14	63.84
Farmer organization	11	6.21	70.06
Radio	5	2.82	72.88
Others	2	1.3	74.01

Source: analyzed from own data, 2019

Major problem in rice production in the study area

Farmers in the study area faced with the different challenge in producing sufficient rice to meet growing consumer demand of rice while maintaining the quality and quantity of their production Diseases; Diseases have been identified one of the main factor for low productivity of the rice se in the study area. About 7.30 % from those problem identified by the house hold survey. In other hand lack of market is the second biggest challenge of rice producer in the study area this is occur due to price fluctuation delayed in market due to infrastructure facilities such as rode is about 5.62 % of those problems. Lack of seed and fertilizer is also appear to be a biggest challenge in the study area due to shortage of supplementation from the government and research center side is also a big problem for those rice producers in the study area which accounts up 2.25% and 0.56% respectively.

Table 14: major problem in rice production

Problem	Number	Percent	Cumulative
Lack of seed	4	2.25	2.25
Lack of fertilizer	1	0.56	2.81
Disease	13	7.30	10.11
Lack of market	10	5.62	15.73
Other	3	0.56	16.28

Source: analyzed from own data, 2019

Credit problem house hold head face

Credit can help farmers in emergency time when there is a shortage of money to buy seed, fertilizer, and pesticide and herbicide rather than this it also help in socioeconomic activities of house hold heads. Most of all access to credit during rain shortage, sudden crop disease, flooding on crop land in all those time having access to credit will hill those problems and help farmers to return to normal farming practices .in spite of this if there is no access to credit there is problem occurs as the survey conducted in the study area those house hold who engaged in rice production also faces problems such as ,bank lone about 19.7% of house hold had this issues also about 1.6% of house hold faces problem of re payment period in which they cover all the amount of the credit they took were so short .most of all the biggest challenge in the study area in access to credit is religion of house hold which account about 26 % because of this the house hold have no willingness to take credit .

Table 15: credit problem

Credit problem type	Number	Percent	Cumulative
Bank lone not available	23	19.17	30
Lone from informal source not	1	0.83	50
Re payment term	2	1.67	51.67
Other/religion	32	26	67.78

Source: analyzed from own data, 2019

Purpose why house hold adopted improved rice technology

Adoption of new agricultural technology, such as the high yielding varieties this new agricultural technology influenced the poor directly, by raising incomes of farm households, reduce cost of production , offsetting environment and making house hold food secured also plays a vital role in ecosystem such as improving soil fertility due to less application of chemical and fertilizer to the land for those improved verities because of their high yield performance . as indicated from the study about 25.99% of house hold choose improved variety of rice because of its improved yield performance as compared to the local ones and about 15.25 chose improved rice technology as a result of its reduced cost of production ,1.69% of house hold use it for animal feed ,2.26 of the hold take it due to ability of improved rice technology in improving soil fertility and 0.56% choose it because of food security value with a cumulative value of 46.89 .

Table 16: purpose of IRV

Purpose	Percent	Cumulative
Improve yield performance	25.99	27.12
Reduced cost of production	15.25	42.37
Offsetting environment	0.56	42.94
Improve soil fertility	2.26	46.33
Food security	0.56	46.89
Other/ for animal feed	1.69	48.59

Source: analyzed from own data, 2019

As a result obtained from FGD (focus group discussion) and key informant interview rice has different value in farm household. There is an increase in rice production due to higher price value of rice grains over other cereals. The increased rice consumption habit of farm household is because of Possibility of using in a range of traditional food recipes such as injera, dabo, tella, and katikal. Also rice Provide by-products such as straws and husks that shall be fed to livestock and/or used as alternate source of fuel for farm household in the study area as the result of the FDG shows.

Other discussion made with researcher showed that Rice is a vital cereal crop for Food & nutritional Security income generation, Poverty alleviation and Socio economic growth of the *woreda*. Even if a little is done on using the starch of rice in this study area as a center for future there are some movement going to happen like, domestic and industrial uses. Industrially, its applications are numerous and it is used in various modern industries including the manufacturing of textile, paper, adhesives, insecticides, paints, soaps, explosives and such derivatives as dextrin and nitro starch. Industries use the product mainly as binding, diluting adhesive and water absorber agent in their production process. The source of supply of starch is local as well as import level in order to support farm household in the study area. Also discussion with *woreda* agri-bureau confirm that rice production has brought a significant change in the livelihood of farmers and created job opportunities for a number of citizens in the study areas of the *woreda*. The demand for improved rice technologies is increasing from time to time from different stakeholders. This, therefore, calls for the need to establish a strong research and development system to bring about productive, sustainable, stable, and profitable rice farming system in the rice producing areas.

Descriptive statics on association among food security and rice technology adoption Descriptive statics on HouseHold Food Balance Model

Household food balance model were employed to evaluate the house hold food security status of the study area in which the value NGA (net grain available in kumtal in 2009/2010 production year is computed by using adding grain production , grain bought ,Quantity of food aid obtained ,grain obtained through gift or remittance ,Meat, meat based products and poultry , Dairy and dairy based products and subtracting Post harvest losses due to grain pests, disasters, thievery, Quantity of grain reserved for seed, grain sold , Grain given to others within. All food item which is a means of from which food for house hold was included. those food items includes cereals, vegetables, root and tubers also milk and dairy products take in to account to measure the food security status of the households in the study those food items converted in to kilocalorie based on FAO (2003) food energy calorie conversion factor then the kilocalorie got divided to days in one year and to each members /family size.

Food security status in adoption of improved rice variety

As specified from the table from the total number of 178 sampled households, 160 was found to be participate on production of improved rice technology while 18 house hold heads was found that they didn't participate in improved rice technology. so the survey result displays that from the overall sampled house hold heads of improved rice technology producers 93.87 % of house hold found to be food secured and 46.67 house hold heads were food in secured . on other side from 18 none adopter house hold 6.13% were food secured and 53.33% was found that food in secured. From this result of survey, it is conceivable to say that those house hold engaged in improved rice technology are more food secured from those who didn't adopted improved rice technology

Table 17: Food security status of adopter and non-adopter

Food security status	Adopter		Non adopter		Total		p-value
	N	%	N	%	N	%	
Food secured	153	93.87	10	6.13	163	91.5	0.000***
Food in secured	46.67	8	53.33	15	8.4		7

Source: analyzed from own data, 2019

Socioeconomic and demographic table for food security status of household

The education status of household implies that majority of the food secured household there in the better position to access information, have better understanding and adopt new improved farm techniques. Njoku (1991) observed that formal education has a positive impact on food security.as the result of the study shows about 92.80% who had a formal education was food secured than those had no formal education /who have no ability to write and read 89.39 so education has effect on food security status of hold in 5% level of significance .

Table 18: Socioeconomic and demographic table for food security status of house hold

Variables	Food secured		Food in secured		Total		p- Value
	N	%	N	%	N	%	
Sex male	157	91.87	14	8.92	171	96.06	0.56
Female	6	85.7	2	14.29	8	3.93	
Education							
Not write & read	59	89.39	7	10.61	66	37.07	0.05**
Formal	104	92.80	8	7.4	112	62.92	

Source: analyzed from own data, 2019

Socioeconomic factors on food security

The result implies that families with small household size are more food secure than those with large household size. This is because increase in members of household added more responsibilities to household heads especially when many of the family member depend totally on the household head. Again, as household size increases, income per head declines and the less food secure the household becomes. This result agrees with the findings of Babatunde *et al.*, (2007), which revealed that as the household size increases, the probability of households being food secure decreases. The result from the study shows that there is a mean difference between food secured and in secured in terms of family size at 10% level of significance.

House hold who adopted a new technology of improved rice variety from the study area was found food secured than those who didn't adopted the improved rice variety this is due to the increase yield performance, drought and disease resistance of improved rice variety compared to the local

One .so house hold who adopted new technology were food secured in 10% level of significance than those who didn't use improved rice variety.

Table 19: Socioeconomic factors on food security

Variable	Food secured (N=163)		Food in secured (N=15)		
	mean	Std	Mean	Std	p-value
Family size	5.0	2.12	6.13	1.84	0.06**
Farm experience	4.01	2.46	3.3	1.67	0.29
Livestock holding(TLU)	2.2	2.48	2.7	2.9	0.47
Total land holding	2.26	8.89	1.52	0.46	0.74
Total cultivated land	1.52	0.43	1.52	0.46	0.98
Land for improved rice	0.38	0.21	0.24	0.14	0.06**

Source: analyzed from own data, 2019

4.2. Econometric Results

In this sub-section, the results of the tobit regression model, logistic regression model is presented and discussed. Adoption decision of farm households is influenced by different socioeconomic, technical and institutional factors. Different variables are important across different space and over time in explaining adoption of technologies by farmers. Many factors are hypothesized to influence the adoption of improved rice varieties based on theoretical models and empirical evidences. The five explanatory variables which have been found to significantly influence the decision by the sample farm households with regard to whether or not to adopt improved rice varieties and the five explanatory variables which have been found to significantly influence intensity of adoption of improved rice are interpreted and discusses below.

Determinants of adoption and intensity of use of improved rice varieties

This segment presents maximum likelihood estimates of Tobit model to identify determinants of adoption and intensity of use of improved rice varieties this Tobit estimates measure factors that affect adoption intensity of improved rice varieties. The tobit estimate results indicate that once the decision to adopt IRV has been made, factors that affect amount of land allocated to IRV might be different or the same. A total of 15 explanatory variables, five variables become significantly affect adoption improved rice variety.

4.2.1. Statistical analysis and discussion

The researcher further examines the collected data with probit, Tobit and ordered logistic regression to determine if the variables have effect on the adoption of IRV and food security status of household respectively.

4.2.2. Model diagnosis test results

Multi-co linearity is a statistical phenomenon in which there exists a perfect or exact relationship between the predictor variables. When there is a perfect or exact relationship between the predictor variables, it is difficult to arise with reliable estimate of their individual coefficients. This finally results in incorrect conclusions about the relationship between outcome variable and predictor variables.

There are several ways of diagnosing the presence of multi-co linearity: Examination of Correlation Matrix, link test, goodness of fit test, Variance Inflation Factor (VIF) and Eigen system Analysis of Correlation Matrix. In this study we used Correlation Matrix, link test, goodness of fit and variance inflation factor. According to Gujarati (2004) by the rule of thumb is that if the correlation coefficient between two explanatory variables is high, say, in excess of 0.8 and below -0.8, then multi-co linearity is a serious problem. With this approach correlation coefficient between two explanatory variables found to be by far below 0.8 in absolute terms indicating no serious problems of multi-co linearity between variables. Another use of correlation test it is employed before regression.

The model goodness of fit test of the logistic regression justify that the model is robust enough to explain the dependent variable. The Pseudo R² statistic of the model is 0.2214 which lies between 0 and 1 an evidence that the variable is well fit for the model and the independent variable could explain the dependent variable

Link test for model specification error is performed for the other ordered dependent variable with a null hypothesis shows there is no model specification error. If the p-value of hatsq is not significant then we reject the null hypothesis and confirm that our model is correctly specified. For factors affecting food security the p-value is 0.42 this indicates that the value is not significant and we fail to reject the null hypothesis and accept that there is no model specification error. For the ordered logit the p-value is 0.256 this implies that the value is not significant and we reject the null hypothesis and confirm that there is no model specification error.

Table 20: Diagnostic test result for regression models

Tests	Test name	Intensity of adoption tobit	Factor affecting food security logit	Order logit
Gof	Pearson's (chi ²)		0.2214	–
pwcrr	Multi collinearity	Min = 0.0005	Min = 0.0100	
		Max= 0.3420	Max=0.4340	
Link test	hatsq		0.42	0.256
Vif	Mean vif	1.22	1.12	1.17

Source: analyzed from own data (2019)

Lastly, the VIF measures how much the variance of an estimated regression coefficient increases if your predictors are correlated. A VIF around 1 is very good. There are some guidelines we can use to determine whether our VIFs are in an acceptable range. A rule of thumb commonly used in practice is if a VIF is > 10 , you have high multi co-linearity. In this case, the values around 1, are in good shape, and can proceed with regression. In all the three models have VIF value of 1.22, 1.12 and 1.17 for intensity of adoption, factor affecting food security and ordered logit respectively.

4.2.3. Intensity of adoption by using Tobit model

As result from this survey relives that Education not only facilitates adoption but also enhances productivity, especially among adopters of improved technology. Alene and Manyong (2007) found that education had a greater impact on cowpea yields among adopters of improved varieties relative to its effect on yields among non-adopters here the same for rice technology adoption. House hold who had a better education or house hold who is literate are more near to improved technology also they have ability to update them self through practice and acceptance of new technology than the illiterate one as the result shows that education is one factor that influence house hold at 1% level of significance wither to adopted new technology or not.

Table 21: intensity of adoption by Tobit model

Variables	Estimated Coefficient	Std .Err	P- value	Marginal effect (dy/dx)
Sex	-0.021	0.062	0.753	-0.212
Age	-0.004	0.002	0.063*	-0.004
Education of HH	0.146	0.052	0.006***	0.146
Family size	-0.015	0.013	0.228	-0.015
Extension contact	0.195	0.053	0.000***	0.195
Training	0.225	0.051	0.620	-0.025
Distance to nearest market	0.007	0.001	0.185	0.010
Access to credit	0.083	0.046	0.072**	0.083
Membership corporative	0.086	0.046	0.066*	0.086
Total livestock unit	0.003	0.008	0.667	0.003
Proportion of land by IRV	0.087	0.105	0.410	0.087
Cons	0.718	0.123		
Sigma	-0.281532	0.1637738		
Number of obs=178	LR=00.62	R ² =0.3774	Prob>chi=0.000	Loglikelihood= -49.99819

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

Source: analyzed from own data, 2019

NB: ***p<0.05, **p<0.05, *p, 0.1

Extension services play a major role as a media in disseminating new and improved farming techniques. Extension contacts are also needed for communicating farmers experience and problem to researchers for modification of current technologies into improved technology in this extension service has a significant effect on adoption of improved rice technology at 1% level of significance.

Farmers' membership in cooperative, which is used as a measure for the role of association in the adoption process, has a positive and significant influence on adoption of improved rice variety at five percent level of significance, implying that farmers who are members of farmer cooperative are more likely to adopt improved rice variety than others. A probable reason for this result relates to the fact that farmer cooperative provides facilitate information sharing platforms between farmers and also provides information about the price, profitability, status of the new technology and the provision of credit services for member farmers. As a result, farmers in cooperatives tend to adopt improved rice variety faster than farmers who are not members. Result show that being member of farmer cooperatives increases the probability of improved rice variety adoption rate.

Other variable which come significate from this study is Access to credit is among key elements for improving agricultural production and poverty reduction. Credit can facilitate farm households to purchase the needed agricultural inputs and enhance their capacity to effect long term investment in their farms. These results suggest the need for targeting credit interventions to farm households who are credit constrained for improving access to credit and the adoption of agricultural technologies. So house hold who had access to credit adopt technology more than those who have access to technology in 5% level of significance.

4.2.4. Factors affecting adoption of IRV

In this section probit model were used to analyze factor influencing decision to adopt improved rice variety. So as a result from total of sixteen variables four variables has positive and significant impact where as one variable has negatively significant impact on household rice technology adoption. Education is the major demographic characteristic explanatory variable that differentiates adopters and non-adopters in all adoption studies. Farmers who are more educated are generally more open to innovative ideas and new technologies that promote technical change.

Table 22: Probit model analysis for factors affecting adoption of IRV

Variables	Estimated			Marginal effect (dy/dx)
	Coefficient	Std .Err	P- value	
Sex	-0.276	0.708	0.769	-0.048
Age	-0.175	-0.179	0.328	0.05
Education of HH	0.999	0.460	0.030**	0.053
Farm experience	-0.157	0.747	0.833	-0.004
Access to credit	1.157	0.532	0.048**	0.149
Extension contact	0.854	0.465	0.067*	0.042
Training	0.674	0.582	0.246	0.028
Membership of cooperatives	0.981	0.487	0.840	0.027
Total livestock	-0.816	0.948	0.399	0.002
Food security	-0.991	0.263	0.000***	-0.290
Proportion of land by IRV	0.359	1.153	0.756	0.012
Total land	-0.729	0.173	0.913	0.052
Cultivated land	0.180	0.729	0.805	0.055
Distance to market	0.001	0.008	0.668	0.278
Family size	-0.186	0.110	0.090*	0.92
Cons	2.470	1.668		
Number of obs=178	LR=67.00	R ² =0.5746	Prob>chi=0.000	
Loglikelihood=-24.801945				

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

Source: analyzed from own data, 2019

NB: ***p<0.05, **p<0.05,*p, 0.1

So that education of farm household has a positive and significant impact on adoption of improved rice variety technology at 5% level of significance. Also access to credit has a significant impact in which Accessibility of credit enhanced farmers' capacity to adopt improved rice technology

Which in turn increases farm household productivity in rice production. Likewise access to credit has positive impact at 5% level of significance on household decision to adopt improved rice technology.

Correspondingly the major sources of agricultural information was for farmers are extension agents, in this Regular contact with extension agents make farmers being aware of new technologies and how they can be applied it in their crop land . Contact with extension agent or availability of extension services is perhaps variable that emerged significantly at 10 %level of significance. At the same time food security situation of farm household has positive impact on adoption of rice technology in such a manner that households in order to feed their family they decided to adopt new technology in stable manner so that food security status of house hold encourage household to adoption improved rice technology at 1% level of significance . Family size in the household has a negative and significant influence on adoption of improved rice variety at ten percent level of significance, indicating that farmers with more family size are more likely to use improved rice variety than others. The possible explanation for this result is that rice is a labor intensive crop, which requires more labor for using improved agricultural technologies in rice fields. So that family size is one factor that influence adoption of improved rice variety the relationship between family size and technology adoption was reported to have a similar result in earlier studies such as Hailu (2008) and Moti *et al.*, (2018).

4.2.5. Result to show linkage between food security and adoption of improved rice variety.

Logistic regression model for household food balance model

The result of logistic regression show that four variables were found to have a significant effect on household food security those variables are adoption of improved rice technology ,training on rice production ,membership of cooperative and land allocated by improved rice variety . As indicated in the result adoption of improved rice technology had a significant effect on household food security status, household those uses improved rice technology were food secured.

As noted by Abdulai and Huffman (2014), institutional support services such as access to extension services are important in the dissemination of new technologies and consequently affect their impact on household welfare. From those institutional service training by development agents and research center plays a vital role in household food security through adopting new technology's and increase in production of household which consequently led to food security. Also as stated

by Adegbola and Gardebroek, 2007), Farmers can only adopt modern technologies if they know their inherent characteristics so training is one mechanism to create awareness about the technology they were going to use to fought food insecurity . Training is one of the factor which has a significant effect on house hold food security at 5% level of significance as obtained from survey result.

Table 23: Logistic regression model for house hold food balance model

Variables	Coefficient	std. Err	Z	p>z	Marginal effect (dy/dx)
FARMEXP	0.128	0.17	0.75	0.455	.0026
ADOPTRCV*	3.735	0.97	3.84	0.000***	.368
EXTCONT*	-0.58	0.76	-0.77	0.444	-.0124
TRAINING*	-2.83	1.15	-2.46	0.014**	-.0484
DISTMARK	0.021	0.01	1.47	0.142	.0004
ACRDT*	-1.13	0.87	-1.30	0.193	-.0226
MEMFARMC*	1.67	0.81	2.06	0.040**	.0400
Prop	3.16	1.81	1.47	0.082*	.0655
_cons	-0.102	0.94	-0.11	0.914	

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

Source: Analyzed from own data, 2019

NB: ***p<0.05, **p<0.05, *p, 0.1

Member ship of Cooperatives can help farmers benefit from economies of scale to lower their costs of acquiring inputs or hiring services such as storage and transport. Agricultural cooperatives also enable farmers to improve product and service quality and reduce risks. Membership to cooperative societies significantly increased the probability of uptake of planting depth and fertilizer. Generally, the more farmers are involved in farmer organizations' meetings and activities, the more they will access new information about improved technologies and the more s/he will easily develop positive attitude towards the adoption of production technologies the more

there production increase and eventually the house hold become food sufficient family which help him to overcome food in secured and feed hi. The result shows that farmers who are actively participating in social organizations had increased likelihood of adopting new technology and become food secured so membership of cooperatives had a significant effect on house hold food security at 5% level of significance.

Other result from the econometric analysis provide strong evidence that adoption of improved rice varieties increases income and reduces median level poverty, according to a study conducted in Tanzania by Kassie *et al.*, (2012), said that the effect of improved seed on food expenditure and caloric intake is significantly positive. This result is coherent with previous calculation of the marginal effect of the use of improved rice varieties on per capita food expenditure, so as long as there was a reductions in the level of poverty house hold in other hand become food secured as a result from the survey shows that house hold who adopted improved rice variety and on their farm land are food secured at 10 % level of significance.

Linking between food security and adoption of improved rice verity

The issue of food security is a multifaceted and multi-dimensional problem a single econometrics analysis may not be enough so in order to adders the food security status of the house hold an ordered logit model was applied during the analysis of the data from the study area. . The second method of calculation was in terms of calories. Food secure, marginally insecure, moderately insecure, and severely insecure households were categorized with a value of greater than 2100, 1800-2100, 1500-1800, and less than 1500 kcal, respectively. This type of food insecurity classification was adapted from FAO-WFP (2009).

Table 24: food security status by classification

Food security status of house hold	Proportion of house hold in %
Food secured	91.57 %
Marginally in secured	3.37 %
Moderately in secured	0
Severely in secured	5.06 %

Source: analyzed from own data, 2019

As indicated in the table above the house hold classified in to four categories depending on the house hold day consumption kilocalories recommended per day. Such as food secured, marginally

in secured, moderate and severely in secured, from this classification there is no household fall under moderately food secured from this data the relationship between dependent and intendent variables were analyzed using ordered logit model.

Table 25: ordered logit model for house hold food security analysis

Variables	Marginal effect (dy/dx) food secured	Marginal effect (dy/dx) moderately secured	Marginal effect (dy/dx) food in secured
TLU	-.0014539 (.0077704)	.0005034 (.0027811)	.0009505 (.0049959)
MEMFARMC	0900814 (.0508384)*	-.0311919 (.0175317)*	-.0588896 (.0381393)
TRAINING	-.087291 (.0466069)*	.0302256 (.016774)*	.0570654 (.0348291)
EXTCONT	.024434 (.0369605)	-.0084606 (.012252)	-.0159734 (.0252002)
FAMILYSI	-.0178326 (.0126264)	.0061748 (.0046834)	.0116578 (.0087374)
EDUCHH	-.0319123 (.0467403)	.01105 (.0155629)	.0208622 (.0318473)
MARITAL	.7430269 (.1669003)***	-.2572826 (.1057726)**	-.4857443 (.1434568)***
AGE	-.00196 (.0018778)	.0006787 (.0007068)	.0012813 (.0012351)
SEX	-.0354485 (.0993327)	.0122745 (.0339268)	.023174 (.0658087)
ADOPTRCV	.2086299 (.0626161)**	-.0722408 (.0313812)**	-.1363891 (.050557)*

Source: analyzed from own data, 2019

NB***p<0.01, *p<0.1, ** p<0.05

As a result from the above ordered logit show that membership of crop cooperatives had a significant effect on food secured and moderately food secured house hold at 10% level of significance .Cooperative societies have significant contribution to the food security and poverty reduction Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. The credit availability positively affects the adoption of improved

Technologies Tihamiyu and Leake, (2014). Household who have access to financial service and agricultural input had ability to feed all his family without food shortage.

The second result from ordered logit show that training on adoption of improved technology had effect on food secured and moderately secured household in which the result find that farmers' participation in agricultural trainings has a positive effect, through the adoption of improved technologies, on improvements in food security .

Marital status of the household head is also statistically significant at affecting food security status of household in case of Single headed households are less likely to be food secured and the married one are more food secured due to there is a support between the family in production and also the married . A plausible explanation could be that married farmers have higher social connections and interactions with other farm households which gives them better access to information about agricultural technologies. That help them to increase their production and made them food secured as the result estimated that marital status had positive significant effect on food secured house hold at 1% level of significate whereas negative effect on moderately food insecure and food in secured house hold at 5% and 1% respectively .

Finally Agricultural technologies can also directly contribute to alleviate food insecurity: they can improve crops productivity allowing for higher production quantities both for self-consumption and for increased household income (Kassie et al., 2012), and they can reduce risks of crop failure in case of physical shocks, such as drought or floods (Hagos et al., 2012). In spite of this as the result obtained from this study shows that adoption of improved rice variety had effect on house hold food security, moderately food in secured and food insecure household at 5%, 5% and 10% level of significance respectively.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Summary and Conclusion

This study is conducted in western Ethiopia chewak district on rice producing farmers in order to investigate the contribution of rice technology adoption on house hold food security status. The study used a primary data collected from 178 randomly selected rice grower farmers from three randomly selected “*Kebelles*” in chewek *woreda*. Moreover, regular statistical reports from sources like the Ministry of Agriculture and CSA were reviewed. The study used both descriptive statistics and econometric model results for data analyses. The analysis was made using STATA version 11 software package.

Results of descriptive analysis generally showed that adopter of improved rice varieties differ from their non-adopter counterparts in various demographic, socio-economic and institutional related perspectives between the two adoption groups. Perception of improved verity in yield, marketability, storage, and pest and disease resistance also investigated and house hold food security status also computed. The study also showed that adopters of improved rice varieties as compared with non-adopters were characterized by younger age, better educational status, small family size, good extension contact, access to credit and large proportion of land allocated by rice.

A Tobit model was also used to identify factors that determine adoption and intensity of use of improved rice varieties from 15 variables five explanatory variables become significant. Whereas logistic model employed to see the linkage between adoptions of improved rice verity and house hold food balance model to see food security status of household. From this analysis four variables become significant from eight variables taken in too account to check on house hold food security status. Ordered logistic regression also employed by classifying household kilocalorie intake into four categories as FAO classification suggested, food secured, moderately insecure, mildly and food insecure to make further investigation on district food security. The outcome of the study reveals that five variables out of ten become significant. Those factors are marital status, membership of corporative, training and adoption of improved rice verity.

Further, interlink the results with the theory of adoption, literature and finding of the result discussed above in chapter five. As most of theories of adoption say that adoption is subjected to combination of social, economic and physical status of household, this impacts also united in the

result of this research in a such way that socioeconomic factor such as extension contact, membership on corporative, access to credit and the physical factors such as distance to market and infrastructure have statistically significant impact on farm household. As literatures regarding farmers decision in adoption of improved rice technology in which they play the central role stated in expected theory of adoption the same done for this study in which farm household seen as central point to sorts the adopter from then non-adopter farmers.

Other literature conducted in the country on crop technology also suggests that access of fertilizer, availability of credit, household size; formal education and value-to-cost ratio are the major factors that affect households' decision for fertilizer adoption. Similarly, for adoption of improved rice variety which decision based on those factors found in the household. Theory of reasoned action of adoption were help the farmers in comparing the behavior of improved rice verity production with the traditional technology applied in the farm household in which sated in this study as farmers perception about improved rice variety with the local in terms of yield , disease resistance , marketability and shattering time in between the local variety. Also in this theory of respond action and planed behavior factors affecting adoption of technology of improved rice found out that factors such as age, education, access to credit and cooperative membership has positive impact on household decision to adopt improved rice technology.

Correspondingly, the dynamic diffusion theory which compare the double hurdle model with Tobit shows that Tobit model was more appropriate in assuming the decision regarding adoption and intensity of technology also for this study Tobit found to be more appropriate than double hurdle and this finding shows that socioeconomic (extension, credit, cooperative) and demographic (age and education) has an influence on farmers intensity to adopt rice technology. The food security status of household is covered by state by which household has access to safe, sufficient and nutrition's food was computed in HFBM (household food balance model) based kilocalorie in take stated by FAO (2100) from this the research concludes that household who engaged in farming of improved rice variety has better calorie intake than non- adopter ones. Finally, it can be concluded that rice technology adoption as impact on household productivity in terms of yield and income generation. Above all adopting the technology protects the farmers from poverty and food insecurity.

5.2. Recommendations

This study has inspected factors affecting farmers' decision of modern farm technology adoption by giving special interest on improved rice variety and food security state of house hold in relation with adoption of improved rice technology. The common improved rice technologies stated as being adopted by farmers in the area include improved rice varieties. Socioeconomic characteristics of the farmers are significantly associated with the stated adoption of the various improved rice production technologies in the area. In view of the fact that socioeconomic factors such as, cooperative membership, family size, level of education, contacts with extension agents are seemingly associated with stated adoption the following recommendation was made.

- This study recommends that programs should be designed to improve these socioeconomic characteristics of rice farmers in the *woreda* level. This will go a long way as to increasing the adoption of improved technologies in the area. Farmers should receive more training and knowledge about improved rice technologies through steady flow of information by the extension agents and researcher from both regional and national bodies.
- To enhance food security in the *woreda* nutritional value of rice must be known and Agricultural mechanization (such as improved rice technology) and food science research interventions should be strengthened this could be done in collaboration of *cheweka woreda* and Oromia of bureau agriculture. Motivating farmers to produce a lot of rice and at the same time benefit from selling their production with fair price. In order to get fruitful result in fighting food insecurity in the study areas regional and *cheweka woreda* level agricultural bureau in collaboration with regional and national research center have to work together.
- The other points that have to be considered are seed multiplication and dissemination of improved varieties should be given due attention. The available rice technologies should be promoted extensively so that they can reach the users rapidly and timely. For achievement of this research center have to work with local farm households and see the interest of the local farmers as a priority.
- Other big issues raised in this research is that access of credit and process of repayment has been a bottleneck of farmers. In the study area because of religion credit service and short repayment and interest rate farmer fail in getting support from those sectors. So in order to overcome this issues *woreda* and regional social service and economy department have to

work together in facilitating credit service. So that they can access in long term repayment period and religion considering service such as (Musharba, and Higareba) have to be produced with minimum interest rate in this Oromia finance and economy with micro finance offices is important.

- Also in order to influence farmer's decision on improved rice variety technology adoption in research centers having demonstration sites for new farm inputs in nearby of the farmer is also important, which will make farmers decision rational and easy, and made them confident about their choose this is fulfilled by chewak area research center .

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Appendix

Annex 1 :Multi colinerity test for probit model

. pwcorr ADOPTRCV SEX AGE EDUCHH FARMEXP ACRDT EXTCONT TRAINING MEMFARMC TLU HBC1 Prop TLH_01 TCL_01
DISTMARK

	ADOPTRCV	SEX	AGE	EDUCHH	FARMEXP					
	ACRDT	EXTCONT								
	1.0000									
ADOPTRCV										
	-0.0283	1.0000								
SEX										
	-0.2457	0.1005	1.0000							
AGE										
	0.3294	-0.1447	-0.2767	1.0000						
EDUCHH										
	0.0565	0.0405	-0.0394	0.1458	1.0000					
FARMEXP										
	0.2044	-0.0175	-0.0170	0.2008	0.0665	1.0000				
ACRDT										
	0.3420	0.0823	0.0110	0.0991	0.0533	0.1737	1.0000			
EXTCONT										
	0.1644	0.0295	0.0181	-0.0345	-0.0712	0.0136	0.3338	1.0000		
TRAINING										
	0.2055	0.0713	0.0406	0.0352	-0.0716	0.0822	0.2371	0.0822	1.0000	
MEMFARMC										
	-0.0075	-0.0094	-0.0595	-0.0206	0.2189	0.2190	0.0077	-0.0075	-0.0094	1.0000
TLU										
	-0.4678	-0.0020	0.1163	-0.1109	-0.0861	0.0286	-0.1558	-0.4678	-0.0020	0.1163
HBC1										
	0.1221	0.1158	-0.1069	0.1450	0.0746	0.0096	0.0832	0.1221	0.1158	-0.1069
Prop										
	0.0267	0.0325	0.0098	-0.1249	-0.0518	0.0780	0.0493	0.0267	0.0325	0.0098
TLH_01										
	0.0172	0.0486	0.2739	-0.1045	0.1726	0.2016	0.0618	0.0172	0.0486	0.2739
TCL_01										
	0.1573	0.0307	-0.0506	0.0724	0.0175	0.0781	0.0205	0.1573	0.0307	-0.0506
DISTMARK										
		TRAINING	MEMFARMC	TLU	HBC1	Prop				
		TLH_01	TCL_01							
TRAINING										
	1.0000									
MEMFARMC										
	0.3273	1.0000								
TLU										
	-0.1217	-0.0453	1.0000							
HBC1										
	0.0587	-0.1049	-0.0067	1.0000						
Prop										
	-0.0904	-0.1248	-0.0533	-0.1865	1.0000					
TLH_01										
	0.0464	0.0742	-0.0552	-0.0212	-0.0236	1.0000				
TCL_01										
	-0.1077	0.0532	0.2261	0.0282	-0.1539	0.0466	1.0000			
DISTMARK										
	0.1858	0.1285	-0.0300	-0.1258	0.0489	0.0199	-0.0181	0.1858	0.1285	-0.0300
DISTMARK										
	1.0000									
DISTMARK										
	1.0000									

Annex 2 : Vif test for probit model

. estat vif

Variable	1/VIF	VIF
		1.35
TRAINING	0.739582	
		1.28
TCL_01	0.780440	
		1.27
EXTCONT	0.787232	
		1.25
EDUCHH	0.799031	
		1.22
MEMFARMC	0.819975	
		1.20
AGE	0.832911	
		1.19
ACRDT	0.838695	
		1.17
TLU	0.853994	
		1.15
Prop	0.870580	
		1.13
HBC1	0.885895	
		1.13
FARMEXP	0.886814	
		1.09
DISTMARK	0.918675	
		1.07
SEX	0.936455	
		1.04
TLH_01	0.962854	
Mean		1.18
VIF		

:	1.150466	.5829348	1.97	0.048	.0079352
ACRDT	2.292998				
	.8540117	.4654609	1.83	0.067	-
EXTCONT	.058275	1.766298			
	.6736941	.5801646	1.16	0.246	-
TRAINING	.4634077	1.810796			
	.0981245	.487427	0.20	0.840	-
MEMFARMC	.8572148	1.053464			
	-.0816472	.0948271	-0.86	0.389	-
TLU	.267505	.1042105			
	-.9913293	.2632323	-3.77	0.000	-
HBC1	1.507255	-.4754035			
	.3589434	1.153013	0.31	0.756	-
Prop	1.900921	2.618808			
	.0189043	.1725269	0.11	0.913	-
TLH_01	.3192422	.3570509			
	.1800867	.728928	0.25	0.805	-
TCL_01	1.248586	1.608759			
	.0013356	.008041	0.17	0.868	-
DISTMARK	.0144244	.0170955			
	-.1862814	.1100119	-1.69	0.090	-
FAMILYSI	.4019009	.0293381			
	2.470191	1.668735	1.48	0.139	-
_cons	.8004697	5.740853			

Annex 6 Multi collinearity test for tobit model

. pwcorr ADOPTRCV SEX AGE EDUCHH FAMILYSI EXTCONT TRAINING DISTMARK ACRDT MEMFARMC TLU Prop

	ADOPTRCV	SEX	AGE	EDUCHH
	FAMILYSI	EXTCONT	TRAINING	
ADOPTRCV	1.0000			
SEX	-0.0283	1.0000		
AGE	-0.2457	0.1005	1.0000	
EDUCHH	0.3294	-0.1447	-0.2767	1.0000
FAMILYSI	1.0000	0.0399	0.5140	-0.2462
EXTCONT	0.0005	1.0000	0.0110	0.0991
TRAINING	0.0214	0.3338	1.0000	-0.0345
DISTMARK	-0.2553	0.0205	0.1858	0.0724
ACRDT	0.0250	0.1737	0.0136	0.2008
MEMFARMC	0.0968	0.2371	0.3273	0.0352
TLU	-0.0201	0.0077	-0.1217	-0.0206

	:				
Prop		0.1221	0.1158	-0.1069	0.1450
		-0.1699	0.0832	-0.0904	
		DISTMARK	ACRDT	MEMFARMC	
		TLU	Prop		
<hr/>					
		1.0000			
DISTMARK		-0.0781	1.0000		
ACRDT					
		0.1285	0.0822		
MEMFARMC		1.0000			
		-0.0300	0.2190	-	
TLU		0.0453	1.0000		
		0.0489	-0.0096	-0.1248	
Prop		-0.0533	1.0000		

Annex 7 estat Vif test for Tobit

. reg ADOPTRCV SEX AGE EDUCHH FAMILYSI EXTCONT TRAINING DISTMARK ACRDT MEMFARMC TLU Prop

Source	SS	df	MS			
				Number of obs	=	178
				F(11, 166)	=	6.06
				Prob > F	=	0.0000
				R-squared	=	0.2867
Model	4.63798285		11	Adj R-squared	=	0.2394
	.421634804			Root MSE	=	.26368
	11.5417924		166			
Residual	.06952887					
<hr/>						
				Coef.	Std. Err.	t
				Interval]		P> t
						[95% Conf.
Total	16.1797753	177				
	.09141116					
			ADOPTRCV			
			SEX			

:

	-.0035813	.0020213	-1.77	0.078	-.0075721
AGE	.0004095				
	.1314755	.0484914	2.71	0.007	.0357363
EDUCHH	.2272148				
	-.0131624	.0115779	-1.14	0.257	-.0360213
FAMILYSI	.0096966				
	.1747628	.0492749	3.55	0.001	.0774765
EXTCONT	.2720491				
	.0205641	.047934	0.43	0.668	-.0740747
TRAINING	.1152028				
	.0006955	.0005352	1.30	0.196	-.0003612
DISTMARK	.0017521				
	.0748718	.0428753	1.75	0.083	-.0097793
ACRDT	.1595229				
	.0769716	.0433587	1.78	0.078	-.0086341
MEMFARMC	.1625772				
	-.0032554	.0082102	-0.40	0.692	-.0194654
TLU	.0129545				
	.0827273	.0980217	0.84	0.400	-.1108025
Prop	.2762572				
	.7392882	.1148678	6.44	0.000	.5124979
_cons	.9660784				

. estat vif

Variable	1/VIF	VIF
		1.53
FAMILYSI	0.654127	
		1.44
AGE	0.696546	
		1.29
TRAINING	0.773908	
		1.22
EXTCONT	0.816863	
		1.22
EDUCHH	0.822388	
		1.20
MEMFARMC	0.833730	
		1.15
DISTMARK	0.866971	
		1.15
ACRDT	0.871512	
		1.11
Prop	0.903264	
		1.09
TLU	0.920230	
		1.06
SEX	0.940871	
Mean VIF		1.22

:

Annex 8: Tobit model for intensity of adoption

```
. tobit ADOPTRCV SEX AGE EDUCHH FAMILYSI EXTCONT TRAINING DISTMARK ACRDT MEMFARMC TLU Prop, ll
```

```
Tobit regression                Number of obs    =      178
                                LR chi2(11)         =      60.62
                                Prob > chi2         =      0.0000
Log likelihood = -49.99819      Pseudo R2        =      0.3774
```

ADOPTRCV	Coef. Interval]	Std. Err.	t	P> t	[95% Conf.
SEX	-.0212858 .1026974	.0627995	-0.34	0.735	-.1452691
AGE	-.0041032 .0002265	.002193	-1.87	0.063	-.0084328
EDUCHH	.1462907 .2492052	.0521278	2.81	0.006	.0433762
FAMILYSI	-.0151886 .0096066	.0125591	-1.21	0.228	-.0399837
EXTCONT	.1953508 .3001671	.0530911	3.68	0.000	.0905346
TRAINING	.0255244 .1269921	.051395	0.50	0.620	-.0759432
DISTMARK	.0007624 .0018929	.0005726	1.33	0.185	-.000368
ACRDT	.0833721 .1742512	.0460317	1.81	0.072	-.007507
MEMFARMC	.0860697 .1777971	.0464614	1.85	0.066	-.0056578
TLU	-.0036727 .0137085	.0088039	-0.42	0.677	-.021054
Prop	.0874161 .2965239	.1059165	0.83	0.410	-.1216917
_cons	.7180097 .9621528	.1236624	5.81	0.000	.4738666
/sigma	.2815352 .3138614	.0163738			.2492089

```
18 left-censored observations at ADOPTRCV <= 0
160 uncensored
observations          0 right-
censored observations
```

```
. mfx
```

```
Marginal effects after tobit
y = Linear prediction (predict)
= .88821216
```

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]
SEX*	-.0212858 .859551	.0628	-0.34	0.735	-.144371	.101799	
AGE	-.0041032 35.7528	.00219	-1.87	0.061	-.008401	.000195	
EDUCHH*	.1462907 .719101	.05213	2.81	0.005	.044122	.248459	
FAMILYSI	-.0151886 5.16854	.01256	-1.21	0.227	-.039804	.009427	
EXTCONT*	.1953508 .730337	.05309	3.68	0.000	.091294	.299408	
TRAINING*	.0255244 .674157	.05139	0.50	0.619	-.075208	.126257	
DISTMARK	.0007624 40.6517	.00057	1.33	0.183	-.00036	.001885	

ACRDT*	.0833721	.04603	1.81	0.070	-.006848	.173593
	.578652					
MEMFARMC*	.0860697	.04646	1.85	0.064	-.004993	.177132
	.52809					
TLU	-.0036727	.0088	-0.42	0.677	-.020928	.013583
	2.26302					
Prop	.0874161	.10592	0.83	0.409	-.120176	.295009
	.368871					

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

Annex :9 House hold food security by household food balance model depending up on kilocalorie in take into $HBC \geq 2100$ and $HBC \leq 2100$

. tab HBCFS

HBCFS	Freq.		Percent
	Cum.		
0	8.43	15	8.43
1	100.00	163	91.57
Total	100.00	178	

Annex :10 Demographic factors for food security

Variables	Food secured		Food in secured		Total		p- value
	N	%	N	%	N	%	
Sex male	157	91.87	14	8.92		96.06	0.56
Female	6	85.7	2	14.29	7	3.93	
Education							0.05**
Not write & read	59	89.39	7	10.61	66	37.07	
Formal	104	92.80	8	7.4	112	62.92	

Annex 11: Food security category based on FAO classification

. tab HBC1

HBC1	Freq.		Percent
	Cum.		

1	91.57	163	91.57
2	94.94	6	3.37
4	100.00	9	5.06
Total	100.00	178	

Annex 12: Collinearity test for logit model for factor affecting household food security

```
. pwcorr HBCFS FARMEXP ADOPTRCV EXTCONT TRAINING DISTMARK ACRDT MEMFARMC Prop
```

	HBCFS DISTMARK	FARMEXP ACRDT	ADOPTRCV	EXTCONT	TRAINING	
HBCFS	1.0000					
FARMEXP	0.0792	1.0000				
ADOPTRCV	0.4349	0.0565	1.0000			
EXTCONT	0.0100	0.0532	0.1751	1.0000		
TRAINING	-0.0815	-0.0712	0.1644	0.2164	1.0000	
DISTMARK	1.0000					
ACRDT	-0.0131	0.0665	0.2044	0.0964	0.0136	-
MEMFARMC	0.0781	1.0000				
Prop	0.1183	-0.0716	0.2055	0.1258	0.3273	
	0.1285	0.0822				
	0.1800	0.0746	0.1221	0.1382	-0.0904	
	0.0489	-0.0096				
	MEMFARMC					
	Prop					
MEMFARMC	1.0000					
Prop	-0.1248					
	1.0000					

Annex :13 Logistic model for food security

```
. logit HBCFS FARMEXP ADOPTRCV EXTCONT TRAINING DISTMARK ACRDT MEMFARMC Prop
```

```
Iteration 0: log likelihood = -51.455436
Iteration 1: log likelihood = -45.562049
Iteration 2: log likelihood = -40.39885
```


DISTMARK	.0004442	.0003	1.46	0.144
	-.000152	.001041	40.6517	
ACRDT*	-.0226103	.01981	-1.14	0.254
	-.061431	.016211	.578652	
MEMFARMC*	.0400865	.02395	1.67	0.094
	-.006853	.087026	.52809	
Prop	.0655286	.04532	1.45	0.148
	-.02329	.154347	.368871	

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

Annex 15: Link test for logit model

. linktest

```
Iteration 0: log likelihood = -51.455436
Iteration 1: log likelihood = -42.519447
Iteration 2: log likelihood = -35.460693
Iteration 3: log likelihood = -32.057434
Iteration 4: log likelihood = -31.375841
Iteration 5: log likelihood = -31.281764
Iteration 6: log likelihood = -31.281229
Iteration 7: log likelihood = -31.281229
```

```
Logistic regression                Number of obs   =       178
                                   LR chi2(2)        =       40.35
                                   Prob > chi2        =       0.0000
Log likelihood = -31.281229        Pseudo R2      =       0.3921
```

HBCFS	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
_hat	.7759279	.3194369	2.43	0.015	
	.149843	1.402013			
_hatsq	.0882759	.1097407	0.80	0.421	-
	.126812	.3033637			
	-.06581	.4671587	-0.14	0.888	-
_cons	.9814243	.8498043			

Annex 16: estat gof test for ordered logit

. estat gof

Logistic model for HBCFS, goodness-of-fit test

```
number of
observations =
178 number of
covariate patterns =
```

178

Pearson chi2(166) =
179.68

Prob > chi2 = 0.2214

Annex 17: Vif test for ordered logit

```
. reg HBC1 TLU MEMFARMC TRAINING EXTCONT FAMILYSI EDUCHH MARITAL AGE SEX ADOPTRCV , r
```

Linear regression	Number of obs	=	178
	F(10, 167)	=	1.37
	Prob > F	=	0.1960
	R-squared	=	0.1888
	Root MSE	=	.62681

HBC1	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]
TLU	-.0046523	.0150501	-0.31	0.758	-.0343653
MEMFARMC	-.2096053	.1168827	-1.79	0.075	-.4403634
TRAINING	.1564468	.0929014	1.68	0.094	-.0269657
EXTCONT	-.0727661	.0923002	-0.79	0.432	-.2549917
FAMILYSI	.0314508	.0295635	1.06	0.289	-.0269155
EDUCHH	.087853	.0981197	0.90	0.372	-.1058618
MARITAL	-.1255797	.1193229	-1.05	0.294	-.3611555
AGE	.0044199	.0039594	1.12	0.266	-.0033969
SEX	.2435416	.4645238	0.52	0.601	-.6735542
ADOPTRCV	-1.279208	.544135	-2.35	0.020	-2.353478
_cons	1.973199	.6594419	2.99	0.003	.6712819

```
. estat vif
```

Variable	VIF
AGE	1.34
FAMILYSI	0.746866
TRAINING	1.29
MARITAL	0.772847
MEMFARMC	1.24
EDUCHH	0.803401
SEX	1.20
	0.836770
	1.19
	0.842909
	1.17
	0.856900
	1.14
	0.875402

	1.05
EXTCONT	0.954512
	1.04
ADOPTRCV	0.959907
	1.03
TLU	0.967369

Mean	1.17
VIF	.

Annex 18: Ordered logit for food security

Ordered logistic regression	Number of obs	=	178
	Wald chi2(10)	=	373.82
	Prob > chi2	=	0.0000
Log pseudolikelihood = -49.417106	Pseudo R2	=	0.1971

HBC1	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]
TLU	.023518	.1257782	0.19	0.852	-.2230027
MEMFARMC	-1.457121	.8455721	-1.72	0.085	-3.114412
TRAINING	1.411984	.6729953	2.10	0.036	.0929376
EXTCONT	-.3952342	.5888372	-0.67	0.502	-1.549334
FAMILYSI	.2884532	.1880707	1.53	0.125	-.0801586
EDUCHH	.5161999	.7686179	0.67	0.502	-.9902635
MARITAL	-12.0189	.8693358	-13.83	0.000	-13.72277
AGE	.031704	.0312688	1.01	0.311	-.0295817
SEX	.5734008	1.597739	0.36	0.720	-2.558109
ADOPTRCV	3.704911	1.088697	-3.10	0.002	-5.50852
/cut1	-8.745757	2.567619			-13.7782
/cut2	-3.713315	2.56976			-13.12716

Annex 19: mfx one for food secured household

Ordered logistic regression	Number of obs	=	178
	Wald chi2(10)	=	373.82
	Prob > chi2	=	0.0000
Log pseudolikelihood = -49.417106	Pseudo R2	=	0.1971

HBC1	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]

	.023518	.1257782	0.19	0.852	-.2230027
TLU	.2700387				
	-1.457121	.8455721	-1.72	0.085	-3.114412
MEMFARMC	.2001701				
	1.411984	.6729953	2.10	0.036	.0929376
TRAINING	2.731031				
	-.3952342	.5888372	-0.67	0.502	-1.549334
EXTCONT	.7588654				
	.2884532	.1880707	1.53	0.125	-.0801586
FAMILYSI	.6570649				
	.5161999	.7686179	0.67	0.502	-.9902635
EDUCHH	2.022663				
	-12.0189	.8693358	-13.83	0.000	-13.72277
MARITAL	-10.31504				
	.031704	.0312688	1.01	0.311	-.0295817
AGE	.0929898				
	.5734008	1.597739	0.36	0.720	-2.558109
SEX	3.704911				
	-3.374713	1.088697	-3.10	0.002	-5.50852
ADOPTRCV	-1.240905				
<hr/>					
	-8.745757	2.567619			-13.7782
/cut1	-3.713315				
	-8.090517	2.56976			-13.12716
/cut2	-3.053879				

Annex 20: mfx two for moderate food secured household

```
. . margins, dydx(*) predict(outcome(2))
```

```
Average marginal effects          Number
of obs      =      178 Model VCE    : Robust
```

```
Expression   : Pr(HBC1==2), predict(outcome(2)) dy/dx
w.r.t.      : TLU MEMFARMC TRAINING EXTCONT FAMILYSI EDUCHH
MARITAL AGE SEX ADOPTRCV
```

	Delta-method				
	dy/dx	Std. Err.	z	P> z	
	[95% Conf. Interval]				
	.0005034	.0027811	0.18	0.856	-
TLU	.0049475	.0059544			
	-.0311919	.0175317	-1.78	0.075	-
MEMFARMC	.0655534	.0031697			
	.0302256	.016774	1.80	0.072	-
TRAINING	.0026507	.063102			

Calf	0.25	Camel	1.25
Weaned calf	0.34	Sheep and goat (adult)	0.13
Cow and Oxen	1.00	Sheep and goat (young)	0.06
Horse	1.10	Chicken	0.013
Donkey (adult)	0.70		

Source Stock *et al.*, (1991)

Annex 23: Food energy factor (KCAL/100g)

Food item category	Food item	KCAL/100g
Cereals	Teff	357
	Barley	378
	Wheat (70-74% extraction)	403
	Wheat (97-100% extraction)	378
	Macaroni, spaghetti	412
	Other cereal	412
Fruits and vegetable	Root and tubers	384
	Vegetables	357
	Fruits	360
Legumes	Legumes	407
Milk and milk products meat	Milk and milk products	387
	Meat	427
	Egg	368

Annex 24: Survey Questionnaire

Instruction: Please introduce yourself before starting the interview, the institute you are working in and explain the objective of the survey. Please ask each question patiently until the farmer get the point. Fill the answers to the question accordingly to the farmer's response.

1. General information

- 1.1. Questionnaire no: _____ 1.2. Date of interview (DD/MM/YYYY): _____
 1.3. Zone: _____ 1.4. District: _____
 1.5. Peasant Association (Kebele) _____
 1.6. Name of respondent _____
 1.7. Name of Enumerator _____

2. Household Characteristics

- 2.1). Name of household head: _____
 2.2). Sex of household head: 1. Male headed 2. Female headed
 2.3). Age of household head (year): _____
 2.4. Marital status of the household head 1. Married 2. Single 3. Divorced 4. Widowed
 5. Never married 6. Other, specify.....
 2.5. Educational level of household head in grade ----- (Then enter grades completed)
 2.6 Education level of the partner of the household head----- (Then enter grades completed)

3. Demographic Characteristics

3.1. Number of family members by sex and age Composition

Name of members	Age of members	Sex of members	Education level in grades	Are they help you in rice production	In which activity they involve
1.					
2.					
3.					
4.					
5					
6					

3.2 Farming experiences of household head, since he started farming [in year]: _____

3.3. How many of your family members do permanently work on farm activities: _____

4. Socio economics Characteristics

4.1. Rank the source of income for your household, as a family in order of importance?-----

Ser no.	Income source	Amount Birr per year on average	Rank
	Crop		
	Animal husbandry		
	Craft		
	trade		
	Forest		
	Other business		
	remittance		
	Wage/salary		
	Other specify		

4.2. Your house holds experience in rice farming? -----

1.	Experience of household in rice farming	-----in years
2.	Experience of household in improved rice technologies	----- in years
	1=improved variety	----- in years
	2=fertilizer use	----- in years
	3=row planting	----- in years
	4=use of herbicide& pesticide	----- in years
	5=pre harvest Managements	-----in years
	6 =post harvest Managements	----- in years

4.3. Landholding status (ha):

4.1. Total landholding: _____

4.2. Total cultivable land: _____

4.3. Land allocated for improved rice production in 2009/2010 E.C: _____

4.4. Allocation of your farm land by crops: -----

	Area This year	Area last year	Area before last year	Current year Average production value /in Birr
Maize				
Teff				
Rice				
Sorghum				
Sesame				
Haricot bean				
Eucalyptus				
Other				

4.5. What are the main uses of rice for you in 2009/2010 E.C?

1.) For consumption 2.) For sale 3).Source of livestock feed 4).For other purpose (*Please Specify*)_____5. Multiple choice is possible

4.6 Off-farm activity of the household members

1.	Are you engaged in off-farm activity (i.e., income from agricultural but outside of own farm)? 1=Yes 0=No	Specify the activities involved in:
	1.1 If yes, how much did you get from off-farm activity (income amount in year)	-----Birr
2	2.1 Are you or member of your family engaged in non-farm income activities (income from activities from nonagriculture or non-farm activities): 1=Yes 0=No	Specify the type of activities:
	2.2 How much income you/family earn per year: Birr : _____	Who in family involve in such activities:

5. Cultural practices for rice 5.1.

5.1 What are the current farming culture that you implement while cultivating rice?

Practice used by farmers	Rice
Frequency of land preparation	
Planting time	
Seed rate per hectare	
Fertilizer rate per hectare 1.NPS 2. UREA	
Planting method (1.row planting 2. Broadcast)	
Weeding frequency	
Harvesting time	

5.2 List the major problems in rice production?

- 1.) Lack of seed
- 2.) Lack of fertilizer
- 3.) Disease
- 4.) Lack of rainfall (drought)
- 5.) Lack of market
- 6.) Others (specify)
- 7) multiple choice is possible

6. Livestock production

6.1. Do you practice rearing livestock? 1) Yes 2) No **6.2.**

If yes, fill the table below

Class of livestock	Number			Amount sold last year(2009 E.C)		Unit price		Total price
	Local	Improved	Total	Local	Improved	Local	Improved	
Cows								
Oxen								
Heifers								
Bulls								
Calves								
Sheep								
Goats								
Donkeys								
Horses								
Mules								
Poultry								

7. Adoption status of rice production practices

7.1. Are you aware about adoption? 1) Yes 0) No

7.2 Are you aware about rice production technologies? 1) Yes 0) No

7.2.1. If yes what is the length of time since you first heard about improved rice technologies?

-----Years (in E.C.)

7.2.2 List the technologies you know of: _____;

_____;

_____ - 7.2.3

on improved rice technologies

SN	Rice Technology	Since when you started using the technology (specify the year)	From whom/where did you first heard about the improved rice varieties 1.) Development agent 2).Research Center 3).Neighbor farmers 4). Farmers organizations 5). Radio 6.) Others (specify	If you did not use why? 1. Not aware 2.Unavailability of technology 3.Cost of technology 4.Not relevant 5. Other specify
1	Variety			
2	Fertilizer			
3	Herbicide or pesticide			
4	Pre harvest technologies			
5	Postharvest technologies			

7.3 How much land did you allocated for improved rice technologies in the last three years? -----

No	Rice technology	2008E.C		2009E.C		20010E.C	
		Total Rice Area(ha)	Total area used with technology	Total Rice Area (ha)	Total area used with technology	Total Rice Area (ha)	Total area used with technology
1	Improved varieties						
2	NPS						
3	Urea						
4	Row planting						
5.	Weeding frequency						

6.							
----	--	--	--	--	--	--	--

7.4. How much land did you allocated for improved rice varieties for the last three years?

No	Name of varieties	2006/07 E.C		2007/08 E.C		2008/09 E.C	
		Area(ha)	Yield	Area(ha)	Yield	Area(ha)	Yield
1							
2							
3							
4							

7.5 Why are you using improved rice varieties (multiple answer is possible)? **1.)** Improving yield performance **2.)** Reducing cost of production **3.)** Offsetting environmental effect **4.)** Increasing income **5.)** Improving soil fertility **6.)** food security **7.)** Other (*please specify...*) _____

7.6 Do you face any challenge in adoption process of farm inputs (*-fertilizer and improved seed*)? **1.)** Yes **2.)** No.

7.7 If your answer is Yes for Q#7.10 what are the major challenges that affect the use of these farm inputs (multiple answer is possible)?

1.) Lack of improved seed **2.)** Lack of fertilizer **3.)** Disease **4.)** Lack of information about these technology **5.)** Others (specify). _____

7.8 If you say no for Q#7.6, why you are not in a position to use these improved technology inputs?

1.) High purchase price **2.)** Acceptability problem **3.)** Incompatible weather condition **4.)** Lack of information **5.)** Fear of risk **6.)** Other (*please specify*) _____

7.9. Do you think the improved rice varieties are better than local varieties in terms of the following traits (mark <X> for the better one in the table below)?

Traits	rice	
	Local	Improved
characteristics		
Yield in Qt		
Color		
Taste		
Drought resistance		
Maturity period		
Disease resistance		
Storability		
Food security		

8. Extension Service

8.1. Did you consult with DAs in the last cropping season (2009/10 E.C)? 1.) Yes 2.) No

8.2. If your answer is yes, for the question Q#8.1, how many days did DA contact you in 2009/10 cropping season for purpose of rice production and mgt? _____

8.3. If yes for Q#8.1 how can the DA help you?

1.) Practical assistance at farm 2.) Demonstration 3.) Training at FTC

4.) Other (please specify) _____

8.4. Have you ever attended any demonstration or field days arranged by DAs or research center on rice? 1.) Yes 2.) No

8.5. Have you ever participated in training on rice production? 1.) Yes 2.) No

8.6. Which institution was your first source of information about improved rice and fertilizer?

1) BOA 2) Other farmers 3) Research center (BARC) 4) NGOs (specify)

_____ 5) Relatives 6) other (specify) _____

9. Market service and price

9.1. Do you have market for rice? 1.) Yes 2.) No

9.2. Did you sell your rice crop during the 2009/10 E.C year of cropping season?

1.) Yes 2.) No

9.3. If yes, where do you sell your crop? 1.) At farm gate 2.) village market 3.) District market

4.) Secondary market 5.) Tertiary market 6.) Others (specify) _____

9.4. At what season do you usually sell rice product? 1.) Right at harvest 2.) Later after harvest

3.) Any time I face problem 4.) Other (specify): _____

9.5. In 2009/10:

○ Total production of rice was about: ____ Qt;

○ Total sold amount in was about: ____ Qt

○ Total sales value was about : _____ Birr

9.6. Distance to the nearest market center (in hrs of walk: ____; and in km: _____) 9.7.

Distance to the all-weather road (in hr.) _____

10.) Uses of crop produced

10.1) what are the major crops you cultivate in your farm for 2009/10 cropping season?

Please fill the requested information here below:

Crop	Unit land	Amount produced In Qt	Amount to be used for			
			Seed	Food	Sale	Price per Qt
Maize						
Sorghum						
Wheat						
Rice						
Barely						
Chickpea						
Field pea						
Fababean						
Haricot bean						

11. Participation on off/non-farm income

11.1. Did you participate on off farm activities last year? 1.) Yes 2.)No

Type of off-farm activity	Who in your family involve in	Average annual income

11.2. Did you participate on non-farm activities last year? ? 1.) Yes 2.)No

Type of off-farm activity	Who in your family involve in	Average annual income

11.3. Cash income from livestock production

Type of product	Unit	Quantity produced	Quantity sold(Q)	Unit price(P)	Total (P*Q)
Milk					
Eggs					
Butter					
Cheese					
Others(specify)					
Total					

12. Labor availability

12.1. Did you experience labor shortage in crop farm operation? 1.) Yes 2.) No

12.2. If yes, for which farming operation? 1.) Land preparation 2.) Planting 3.) Weeding (manual) 4.) Herbicide and/or pesticide application 5.) Harvesting 6.) Threshing 7.) Storage

12.3. How did you solve the shortage? 1.) Hiring labor 2.) Debo 3.) Others (Specify) _____

12.4. Did you hire labor for crop production (ploughing of the land, planting, weeding, and harvesting for the last cropping season? 1.) Yes 2.) No

13. Credit availability and use

13.1. Do you have access to credit for you farming operation? 1.) Yes 2.) No

13.2. If yes, from where and how much did you obtained in last cropping season (2009/10) E.C?

Source of credit	Amount or value	Interest rate
Microfinance		
Cooperative/union		
Bank(specify)		
Traders		
Iqub/Iddir		
NGOs (specify)		

13.3. If yes for Q #13.1 for what purpose did use credit you got?

1). to pay school fee 2.) To pay tax 3). To buy agricultural inputs 4). To cover house hold expenditure 5.)To buy livestock 6.) To buy food 7.)Others (specify)_____

13.4. If no, what are your sources of finance for farming operation?

1) Crop sales 2) Livestock sales 3) Off-farm activities 4) Others (specify) _____

13.5. How far is from your home to credit office (in Km) _____

13.6. Do you have any problems in getting credit? 1). Yes 2). No

13.7. If yes, what is the nature of your credit problems?

1.) Bank loans not available 2.) Do not have required collateral 3.) Loans from informal sources not available 4.) Repayment terms are unfavorable 6.) Interest rates are too high 7.) Others (specify) _____

14. Perception of farmers on rice technology attributes

14.1 Characteristics of improved rice varieties as compared to local variety

No	Characteristic	Inferior	The same	Superior
1	Yield	1	2	3
2	Drought resistance	1	2	3
3	Earl maturity	1	2	3
4	Shattering	1	2	3
5	Marketability	1	2	3
7	Disease resistance	1	2	3
8	Logging	1	2	3

15. Cooperative or crop collection center

1.	Is there any farmer's cooperative in your area? 1=Yes 0=No	
2.	If yes, Are you a member of farmers' cooperative 1=Yes 0=No	
	1.1 If yes, what benefit you obtained from engaging in cooperative 1=Market access for crop product 2=Less cost for crop technologies 3=Access to crop technologies (variety, fertilizer) 4=Credit	

16. Food security

1. Is your household food secured throughout the year 1).Yes 2).No?
2. If not for how many months do you face food shortage? (Indicate the months)
3. How long does your farm production last supporting the family?
4. How do you cope with food insecurity situation (during the food deficit months) 1.) Support farm off/non-farm income relatives 2). Depend on relatives 3). PSNP 4) Children support
- 5). NGO aid 6).others specify
5. Has there been any shift in your food security status now compared to that on past 1). Yes I am food secured; 2) I used to be food secure in past but not now? 3).No change
6. If household food security situation improved now than in past, what do you think reason (your assumption)? 1). I adopted improved varieties of crop including rice 2). I now is the bought oxen 3).Use of fertilizer 4). Other reasons (specify)
7. If you become food insecure now than before, do you think that adoption of new varieties of rice has improved you food security status? 1.) Yes 2.) No
9. Do you meet all year round food requirement of your household members from your own farm production 1.) Yes 2.) No

10. If you are not food self-sufficient for how many months does your production covers your food requirement at home? (Indicate in number of months)

HOUSE HOLD FOOD BALANCE MODEAL

Total grain	Rice	Maize	Sorghum	Soybean	Haricot bean	Sesame	Vegetables	Others/ dairy products or poultry	
TG= produced									
TG= grain bought									
TG=Quantity of food aid obtained									
TG=grain obtained through gift									
TG= Post harvest losses									
TG= Quantity of grain reserved for seed									
TG =Amount of grain sold									
TG =Grain given to others within a yea									
MP=Meat, meat based products and poultry									
DP= Dairy and dairy based products									

Focus group discussion and key informant interview questions Focus group discussion (question related to rice production in the area and food security)

1. How was the rice production and productivity pattern of the area?
2. What does it look like the farmers experience in using improved rice technology in the area?
3. Where did the farmers obtain the improved rice technology such as seed, fertilizer and other rice related technology?
4. What is the farmer's response to use different rice varieties both the local and improved?
5. What are the major benefits of improved rice technology production on the household consumption, market in the area?
6. How is the general trend of food security situation of the area?
7. What are the main food crops and food types normally used in the area?
8. Is there a change in a pattern of using different food types throughout the year?

Key informant interview questions for (researchers)

1. In your view what is the role of your department in developing and promoting rice technology?
2. What are the main criteria for selection of improved rice technology to improve household food security?
3. What are the main institutional and other constraints that contribute to strength or weakness of linking between different stakeholders working in area of agricultural technology development advisory service and input supply for rural household?
4. In your opinion how is the farmer's level of acceptance for improved rice variety?
5. What is your observation regarding farmer's food security situation and the role of improved rice technology in improving livelihoods?
6. What are the deterrent factors that hinder farmers from using improved rice technology to enhance food security?
7. What are the methods and approaches your department followed to make the research and development process demand oriented, participatory and sustainable?

Key informant interview for *woreda* agricultural office and experts for different non- government organization

1. How is the importance of rice in chewaka *Woreda*
2. What are the main activates of your organization and its relation to promote rice technology and house hold food security?
3. How do you assess the production and productivity in chewaka *Woreda*
4. How do you characterize the food security situation of small holder farmers in the *woreda* in termers of food availability ,access and utilization
5. How do research centers, agricultural office, privet input dealers and NGOs are working together and what are the main platforms to discuss and work together in an effort to increase rural house hold food security by promoting rice technology?
6. What are the main constraints of rice technology?
7. What are main solution that can utilize to make innovation intuitional arrangement in input supply, technology adoption and working with rice growers to enhance the coverage of improved rice variety production and food security?
8. What are the capacity gaps identified among smallholder farmers to use rice technology (improved seed, fertilizer and chemical, recommended agronomic practice) and making food availability, accessibility, proper utilization and achievable among farmers ?
9. What should be the priority attempt to make farmers food security situation improved?