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BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

DEPARTMENT OF RURAL DEVELOPMENT AND AGRICULTURAL EXTENSION

ADOPTION OF IMPROVED MANAGEMENT PRACTICES OF SORGHUM IN THE CASE OF GONDAR ZURIA DISTRICT, CENTRAL GONDAR ZONE, ETHIOPIA:

MSc. Thesis

By

SIMACHEW YEDEMIE LIYEW

November, 2021

Bahir Dar, Ethiopia

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MSc. Thesis

By

SIMACHEW YEDEMIE LIYEW

Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science (MSc.) In "Rural Development Management"

November, 2021

Bahir Dar, Ethiopia

THESIS APPROVAL SHEET

As a member of the Board of Examiners of the Master of Sciences (MSc.) Thesis open defense Examination, we have read and evaluated this thesis prepared by **Mr. Simachew Yedemie Liyew** entitled "**Adoption of improved management practices of Sorghum in Central Gondar Zone of Ethiopia: the case of Gondar Zuria district**". We hereby certify that the thesis can be submitted as fulfilling the requirements for the award of the degree of Master of Sciences (MSc.) in **Rural Development Management**.

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DECLARATION

This is to certify that this thesis entitled "**Adoption of Improved Management Practices of Sorghum in Central Gondar Zone of Ethiopia: A Case of Gondar Zuria District**" was submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Rural Development Management**" to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Mr. Simachew Yedemie Liyew** (ID. No. 1207203) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for the award of any degree or diploma to the best of our knowledge and belief.

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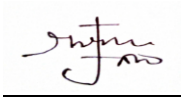
Akalu Teshome (Ph.D)		25/10/2021
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DEDICATION

“This thesis work is dedicated to Gondar agriculture Research Center”

Poverty is a temporary disease because people are transient but goodness is a matter of the heart, not of the pocket.

-Personal expectation

AUTHOR'S BIOGRAPHY

The thesis author was born in Jabitehnan district, Jiga, West Gojam Zone in 1991 from his mother W/ro Yayesh Adamu, and his father Mr. **Yedemie Liyew**. He completed his elementary and primary education at Jiga Tikurwuha school and attended secondary and preparatory education in Damot high school and preparatory school respectively. After passing the Ethiopian higher education entrance qualification Examination in August 2009, he joined Bahir Dar University in September 2009 and he has awarded B.Sc. Degree in Rural Development in July 2012.

Starting from February 2013 up to June 2014, he served as a cooperative extension officer in Bure Zuria district until he has joined the Amhara Agricultural research institute on June 15, 2015. He has been serving as an agricultural extension researcher and he perused his MSc study at Bahir Dar University.

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Last, but not least, I also have great thanks for friends, relatives for highly courage me.

LIST OF ABBREVIATIONS

AGP	Agricultural Growth Program
ANOVA	Analysis of Variance
CSA	Central Statistical Agency
Das	Development Agents
EDHS	Ethiopia Demographic and Health Survey
ETB	Ethiopian Birr
FAO	Food and Agricultural Organizations
GARC	Gondar Agricultural Research center
GDP	Gross Domestic Product
HHs	Households
ICARDA	International Center for Agricultural Research in the Dry Areas
MOA	Ministry of Agriculture
MVP	Multivariate probit model
NGO	Non-Governmental Organizations
RII	Relative Importance Index
TLU	Tropical Livestock Unit
VIF	Variance Inflation factor

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ABSTRACT

Empirical studies on the adoption in agriculture identify various factors for the low adoption of improved management pratices. Sorghum improved management practice technology development and promotion have been done in Gondar Zuria district. However, the factors of adoption and the level of adoption have not been systematically analyzed. Therefore, this study was proposed with the objectives of identifying factors affecting adoption, the status of adoption, and the perception of farmers about improved management practices of sorghum. The study district was selected purposively due to previous intervention in the area. A total of 214 sample respondents were selected randomly and interviewed. The factors that influence the adoption of improved management practices of sorghum were identified by using the multivariate probit model. The adoption level was categorized using the adoption index, and the perception of farmers towards sorghum improved management practice was measured using the Likert scale data analysis method. Based on the multivariate model result family size, sex, farm income, cooperative membership, field day, and landholding were the factors that affect the adoption of improved management practices of sorghum. Moreover, the result indicates that sampled households are found in different categories of adoption, i.e., as non-adopters (0), low-adopters (0.01-0.33), medium adopters (0.34-0.66), and high adopters (0.67-1). Plant growth, biomass yield, grain yield, and early maturity, seed cost, easy management, proper fertilizer, weed, and pest management, and reduce waterlogging were important parameters for farmers to apply improved management practices of sorghum. In the study area, improved management practices of sorghum are mainly affected by total family size, farm income, membership to cooperatives, field day. The adoption status of improved management practices of sorghum are low and farmers give highly perceived. Therefore, to increase the adoption level of improved management practices of sorghum, all stakeholders should consider the perception of farmers and can increase the farm income of the households, wise utilization of family labor, increasing the membership of cooperatives. The adoption level of improved management practices should further promoted by proposed it in the agricultural extension package.

Key words: Adoption, Index, Sorghum, Perception, Household, Adoption level, Multivariate probit model

Chapter 1. INTRODUCTION

1.1. Background and Justification of the study

Agriculture is the science and art of cultivating crops and rearing livestock. Agriculture can help minimize poverty, increase incomes and improve food security for more than 70 % of the world's poor, who live in rural places and work mainly in farming (FAO, 2018). In the world, a lot of people are settled in rural places. Many of the rural farmers are producing very small farms using traditional practices and low inputs other than the land they farm and their household labor (Bruinsma, 2017). At the same time, very few farmers are relatively wealthy and earn relatively high incomes, especially in today's high-income countries where agriculture typically represents less than 2% of national income and employment (Nijs, 2014).

In Africa agriculture is the dominant sector and is almost practiced by all the rural small scale farmers. In the last 30 years, Africa's population has doubled overall and tripled in urban areas. The most direct consequence of this exponential population growth is that the continent now has more mouths to feed. Yet cereal crop yield has been impossible to keep the population demand since it has only increased by a low factor (Bruinsma, 2017).

In Ethiopia in 2019 the share of agriculture for GDP was 33.52 % (World Bank, 2019), it becomes declining from the former contribution. In Ethiopia, about 80% of the population operating agricultural activities, and their life depends on it. Mixed farming is common in Ethiopia; both cultivating crops and livestock. But the most widely accepted and practiced activity is planting crops, such as teff, maize, sorghum, chickpea, sesame, soybean, faba bean, spice, and cotton. From these crops, sorghum (*Sorghum bicolor L*.) common name for corn-like grasses native to Africa and Asia where they have been cultivated since ancient times. It is one of the major crops grown in high, intermediate, and low elevation areas of Ethiopia. Grain sorghum, are the staple food for millions of people in China, India, and Africa (Elbaloula *et al* ., 2014). It can also adapt conditions that are unfavorable for most of the other cereal crops.

In the Amhara region where the crop grows, sorghum is produced highly and has large area coverage; regardless of the production system, the improved variety or local variety, the consumption, and marketing patterns. In the region, most smallholder farmers are dependent on sorghum production for household food consumption and source of income as cash for the household. In addition, sorghum biomass and other by-products of sorghum are the major source of animal feed, fuel and to construct a nest. It can also be used to make traditional homemade beverages and juicy stalks are commonly chewed like sugar cane (Audilakshmi *et al*., 2010).

In Ethiopia, the production volume was 45,173,502 tons with a productivity of 2.69 tons/ha. On the other hand in the Amhara region, 597,440 ha of land was covered by sorghum from which 15,881,921 tons were produced with the productivity of 2.58 tones/ha?? tons/ha (CSA, 2021). However, its productivity in the region as well as in the Gondar Zuria district does not exceed 2.56 tons/ha (CSA, 2021). The productivity of sorghum is low in the study region comparing to the world productivity of 3.45 tons/ha (Hailegebrial Kinfe and Adane Tesfaye, 2018), as well as the national productivity of 2.69 tons/ha (CSA, 2021). This may be due to poor management practices. In this regard, the Ethiopian government has a plan to increase the productivity of sorghum through improved management practices.

Therefore, to alleviate this productivity problem researches have been conducted by different research institutes, universities, and international research organizations. For instance, the participatory varietal selection was done at Dembia, Gondar Zuria, and Takusa midland districts Central Gondar zone during 2015–2016 main cropping seasons to evaluate and select high yielding improved sorghum varieties and other agronomic traits using six varieties and the local variety has high yield than other varieties which gave 3.08 tones/ha (Berhanu Fentie and Mesfin Fenta, 2021).

The other study was improved management practices of sorghum in the study district using local variety (row planting, thinning practice, ridge practice, weeding practice, and fertilizer recommendation NPS and Urea) conducted by (Ertiban Wondifraw *et al.*, 2017) found on average 4.0 tones/ha sorghum grain yield. According to this study, the improved management practice (split Nitrogen application, weeding, tie–ridging and ridging, and thinning) has a 1.86

ton/ha yield advantage over the local management practice in the study area (Ertiban Wondifraw *et al*., 2017). Hence, both the local and improved varieties were evaluated using the improved management practices in all midlands of North Gondar, Amhara region. According to Ertiban Wondifraw *et al*. (2017) the productivity of local sorghum variety with improved management practices was better than improvrd sorghum variety under improved management practices . This showed that the local variety of sorghum under improved management practices was high yielder than the improved variety of sorghum under improved management practices. In line with this, Gondar agricultural research center has tested fertilizer rate determination trial, row planting method, thinning after two weeks planted, ridging and tie-ridging on sorghum productivity for two consecutive years. The result of the study showed that a yield of 4 tons/ha was obtained with fertilizer inputs (87kg N and 46 kg/ha P_2O_5 per hectare); 87 kg/ha of N with split application 1/2 at planting, 1/2 at knee height, row planting 70 cm between rows, thinning using 15 cm between plants after 14 days planting, ridging to avoid a high amount of water and tie-ridging to harvest water at the end of rainfall.

Improved management practices of sorghum and local management practices were demonstrated to analyze the perception of extension workers and farmers. Accordingly, farmers were interested to apply improved management practices of sorghum due to the merits of head size, stem thickness, early maturity, medium height, disease tolerance, and stalk palatability for livestock (Yonas Worku, *et al.*, 2018). In the production year of 2015/2016, the promotion of improved management practices of sorghum was conducted to create a wider demand, strengthen linkage among stakeholders, and intensify sorghum improved management practices in the Gondar Zuria district (Simachew Yedemie and Yonas Worku, 2018).

Even though numerous initiatives to promote improved sorghum management practices among farmers in the Gondar Zuria district, adoption of improved practices is not impressive. As a result, determining why farmers are not adopting improved management practices of sorghum is a huge question that has yet to be answered with substantial evidence for the study area. Thus, the purpose of this study was to examine the adoption of improved sorghum management

practices and farmers' preference for improved sorghum management practices in Gondar Zuria district.

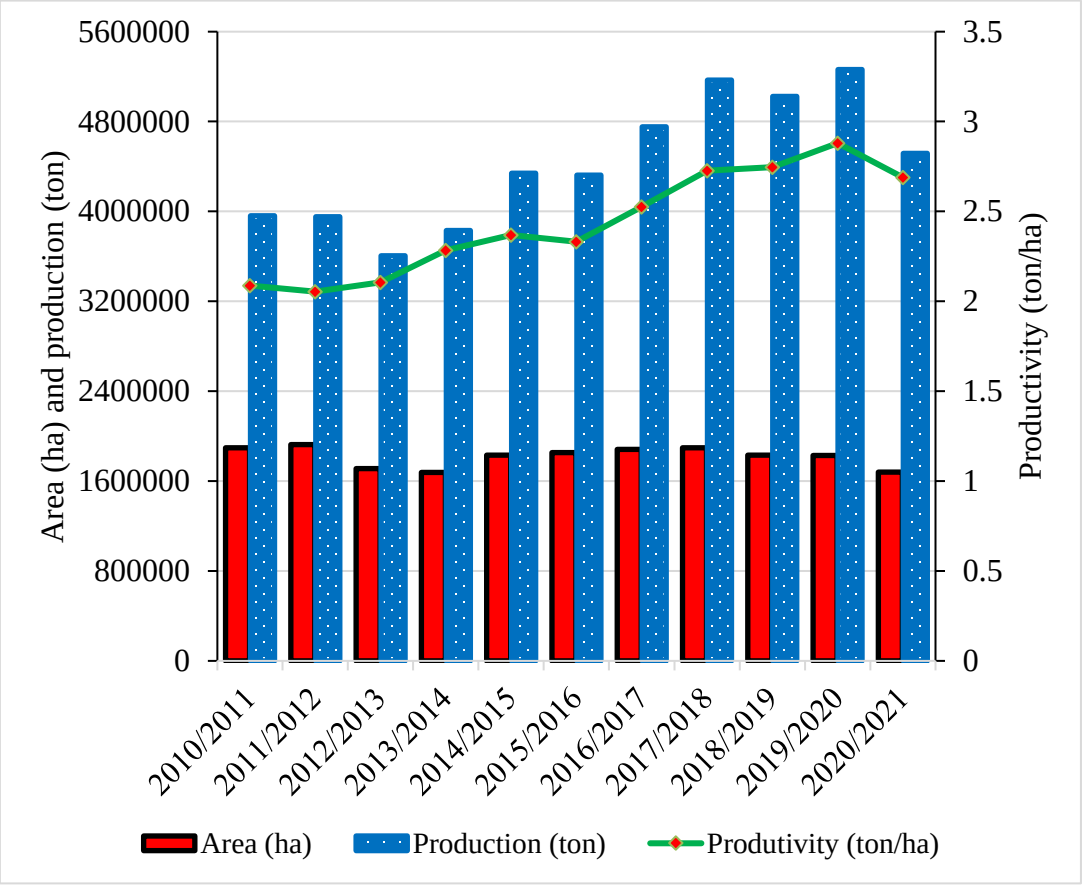

Figure 1.1. Sorghum area coverage, volume produced, and productivity per unit area in Ethiopia

Source: CSA annual survey report from 2010 to 2020

1.2. Statement of the problem

The Ethiopian government aims to increase the productivity of sorghum through improved management practices, improved variety, and applied recommended rate of fertilizer. Researches were conducted to develop improved management practices of sorghum *(*Ertiban Wondifraw *et al*., 2017). National research institute, regional research institutes, and Universities develop different researches on sorghum with the help of international research institutes and donors. From the beginning of the sorghum study in Ethiopia to the present day, 419 sorghum varieties have been released with their agronomic practice recommendation (Asfaw Adugna, 2018; Chemeda Birhanu, 2018). Since the Ethiopian agricultural extension package program was

proposed in 1994, significant efforts have been made to increase the adoption of production technology packages for cereal and other crops (Tesfaye Zegeye *et al*., 2001). In Ethiopia, an approach followed for the development of the extension strategy was prepared, as a decision by policymakers at a workshop, development of a frame for assessing the new practices, field assessment of innovative approaches, synthesis workshop, Write-up of the strategy, and validation, and approval and implementation (MOA, 2014). In Ethiopia also, the agricultural extension activities were not participatory or the approach of the agricultural extension was a top-down approach without including the perceptions, opinions, and indigenous knowledge of farmers (Belay Kassa, 2003). Even if sorghum area coverage in the Amhara region was more than 590,000 ha of land (CSA, 2021), but the productivity is still below the national and the world average yield which was 2.45 tons/ha (CSA, 2021).

Therefore, to alleviate this problem Gondar agricultural research center has developed improved management practices of sorghum in Gondar Zuria district. The improved managements were row-plating, thinning, ridging, and inorganic fertilizer recommendation, and found 4 tons/ha (Ertiban Wondifraw *et al*., 2017). Amhara agricultural research institute in collaboration with the agricultural growth program (AGP-II) has demonstrated and promoted sorghum improved management practices for three production seasons (2015-2018) in Gondar Zuria district with the objectives of creating wider demand (Simachew Yedemie and Yonas Worku, 2018). In addition to this, after the termination of the AGP-II project, Gondar agricultural research center has promoted the improved management practices of sorghum by using different approaches, such as large scale-out, innovation platform, and small-pack approach.

Despite several efforts that have been made to promote and diffuse improved management practices of sorghum, the adoption level is quite low. However, many adoptions studies have been done on crop technologies, livestock technologies, and soil fertility management but no adoption study was conducted on improved management practices of sorghum. For instance, Prasad and Staggenborg (2011), Ministry of Agriculture (2014), Akalu Teshome *et al*. (2016), Mesfin Fenta (2017), Negese Tamirat *et al*. (2017), Ayalew Worku (2019), Nigussie Siyum (2019), Menasbo Gebru (2020), and Muhammed Shako *et al*. (2020) conducted on the adoption of agricultural technologies.

Besides this, few kinds of research on determinant factors of adoption and level of adoption of sorghum have been conducted. Of which, Ermias Tesfaye (2013), Ademe Mihiretu *et al*. (2019), and Muhammed Shako *et al*. (2020) have studies on adoption and a participatory variety selection of sorghum. All adoption studies focused on the of improved varieties than of improved management practices of sorghum. On the other hand, different studies indicated that sorghum variety has been studied individually without management practices (Cavatassi, Lipper, and Narloch, 2011; Kinfe and Tesfaye, 2018; Najib, 2019).

Different works of literature on adoption and the level of adoption of agricultural technologies identifies factors are lack of credit access, small land holding, low farm income, no cooperative membership, small family size, lack of market information, and no extension contact (Ermias Tesfaye, 2013; Tewodros Tefera *et al*., 2016; Muhammed Shako *et al*., 2020; Dabessa Iticha *et al*., 2021). They reported location-specific socio-economic, institutional, infrastructure, demographic, and communication variables significantly affect the technology adoption behavior of the farmers. Further, factors affecting the adoption of agricultural technologies are capital, credit, training, market availability, education level, gender, and age (Kinyangi, 2014). In another case, factors affecting adoptions of sorghum improved varieties are demographic, socio-economic, and institutional (Egge *et al*., 2010). Accordingly to Farid, Tanny, and Sarma (2016), farmers' level of education, training status, communication score, and land holdings have a high positive correlation with the adoption of improved farm practices. On the other hand, age, involvement with cooperative society, and NGO affiliation do not have significant relation with adoption (Sarma, 2016).

Despite considering such kinds of literature, information regarding the level of adoption of cereal crops in general and sorghum production in particular, on locally determinant factors that hinder or promote adoption and variation among farmers were limited in the study areas. In Gondar Zuria district, it was hypothesized that reasons for the rejection of new agricultural technologies may be technical, social, economic, and institutional factors.

However, most of the kinds of literature were based on a single component of the technology mostly other than improved management practices. Specifically, there is no study on the

adoption of improved management practices of sorghum, even there is no empirical evidence has been conducted on the adoption of improved management practices of sorghum in the Amhara region.

Therefore, identifying factors affecting the adoption and the current adoption level of improved management practices of sorghum preference are important concerns for the sorghum producer farmers. Thus with the pursuit of filling these gaps identified in the above problem statements, the current study on the adoption of improved management practices of sorghum in the study area was conducted.

1.3. Objectives of the Study

1.3.1. General objective

- ✓ To analyze factors affecting the adoption and the level of adoption of improved management practices of sorghum in the study area.

1.3.2. Specific Objectives

- ✓ To assess farmers' perception about improved management practices of sorghum in the study area.
- ✓ To determine the adoption level of improved management practices of sorghum in the study area.
- ✓ To identify factors affecting the adoption of improved management practices of sorghum in the study area.

1.4. Research Questions

2. What are the factors affecting the adoption of improved management practices of sorghum in the study areas?
3. What is the adoption level of improved management practices of sorghum in the study area?
4. What are the perceptions of farmers about sorghum improved management practices?

1.5. Significance of the study

The productivity of agricultural sector growth of the world mainly comes from technological improvement. It is proved from the Asian and some Latin countries that the green revolution can increase the productivity of the farmers very significantly. The adoption of agricultural technologies can boost the production and productivity of crops. Similarly, sorghum crop production and productivity are enhanced by different improved technologies. Improved technologies were developed by researchers at different times. Suddenly Gondar Zuria district has one of the best suitable lands for sorghum.

However, the adoption of new improved management practices in the farmers seems indolent. Farmers' are not usually adopting the newly introduced technologies that came to them from any extension agents as it is immediately. They would like to evaluate according to its match with their social, environmental, and economic importance (Bezabih Emana and Hadera Gebremedhin, 2007).

Therefore, having derivers and adoption level of improved management practices of sorghum by farmers have a paramount for the researchers to carry out agricultural studies and for the agricultural extensions to make scale-out and promote which is fitted to the current conditions of sorghum producer farmers. Decision-makers too will benefit from the research output since they require micro-level information to formulate and revise strategies concerning agricultural research and extension.

Thus, the study is assumed to produce very important information on locally determinant factors related to economic, social, cultural, institutional variables and farmers' perception of improved management practices of sorghum. Finally, the information produced from this study will contribute to technology generators, extension agents, input suppliers, and other organizations working in the agricultural sector to improve their service for the production of sorghum.

The findings of this research would enable researchers, education institutions, and people's professions on agricultural development to diverge their research focus based on the real situation and demand of farmers. An understanding of the processes leading to the adoption of

new technologies by farmers will be important to the planning and implementation of successful research and extension programs.

1.6. Scope and limitations of the study

The study was done in Gondar Zuria district of Central Gondar administrative zone, Amhara National Regional State (ANRS) on the issue of adoption of improved management practices of sorghum. Hence, the study was restricted to the assessment of factors affecting adoption, level of adoption, and farmers' perception towards improved management practices of sorghum, to adopt among different improved management practices of sorghum. The sorghum crop is selected for this study due to its importance for food consumption, high coverage in the study district. It is examined local specific factors such as demographic, social, institutional, infrastructure, and access to agricultural extension service. The study was mainly based on the information generated from the sample household survey during a single cropping season using cross-sectional data due to the limitation of time and logistics. Dynamic agricultural farming systems and households' behavior are determinant factors and vary from place to place. Hence, the generalizations might not be possible for the whole region of the country.

1.7. Organization of the Thesis

The first chapter presented the introduction of the study. Chapter two has a literature review. The Literature reviewed is in the area of basic concepts of technology adoption, technology adoption decision theories, technology adoption in the world, and sorghum research and production in Ethiopia. Chapter three has research methodology; incorporates study area description, sampling procedure, methods of data collection, and data analysis. Results and discussions are presented in chapter four. Chapter five concludes the study and presents policy recommendations.

Chapter 2. LITERATURE REVIEW

2.1. The Concept of Adoption and Perception

2.1.1. Basic concepts of adoption of innovation

Different scholars conducted adoption studies on different technology at different times. Innovation is new ideas, information, and practices that are perceived as new and providing ways of adapting to improve the income of the household. The innovation idea that transferred to the society may not be new, but it might be new to an individual that heard for the first time. Diffusion is an idea or a specific technology that is communicated within society over a certain period (Dooley, 1999).

Rogers defines the adoption process as **"**the process by which an innovation is communicated through certain channels over time among the members of a social system**".** (Rogers, 2003). However, for in-depth theoretical and empirical analysis, a specific quantitative definition of adoption is required. Like a definition must be distinguished between individual adoption and aggregate adoption level. Final adoption at the individual farmer's level is defined as the application of new technology in long-run equilibrium when the farmer has full information about the new technology and it is prospective. Therefore, in a process of learning and experimentation, new equilibrium levels can be achieved. On the other hand, most of the theoretical studies of the adoption behavior of individual farmers use static analysis which relates the degree of adoption to the factor affecting it. This study identifies the particular cases of the temporal optimization problems of sorghum producer farmers.

Most of the time, agricultural improved technologies are introduced as a package that incorporates various components, for example, improved varieties, improved management practices, soil fertility management practices, and level of fertilizer. Thus, farmers have their own technology choice. The farmers adopt either all recommended packages or single components of the technology (Feder *et al*., 1982).

2.1.2. Basic concepts of technology adoption

According to Loevinsohn *et al*. (2013) technology is the way and techniques of generating new goods and services. In other words, the study of innovation diffusion is concerned with how, why, and at what rate a new concept or technology spreads among members of a social system. According to Rogers Rogers (2003), technology has two parts: a hardware component that consists of the tool that embodies the technology as material or physical objects, and a software component that contains the information base for the tool. Because the software component of technology is less visible, inventions that rely heavily on software are less visible and have a slower rate of adoption. The perceived attributes of innovations can help in understanding the rate of technology diffusion. Technology adoption is relevant because it is the vehicle that helps most people to involve in a rapidly changing world where technology has become ideal in our lives. Individuals who can't adopt will increasingly limit their ability to participate fully in the financial and convenience benefits of technology. Having Exposure to the factors affecting technology adoption used us to predict and manage who adopts, when, and at what conditions.

Although technology adoption and diffusion are closely related, they are distinct ideas. Technology adoption is defined as the spread of new technology throughout a community over time, whereas technology diffusion is defined as the spread of new technology across a community over time (Thirtle and Ruttan, 1987). While describing the difference between these concepts, Rogers (1962) argued that technology is used in two processes, the processes are adoption and diffusion. Technology is described as an idea, practice, or object that is perceived as new by an individual or groups of society. Technology adoption is the use or non-use of new or improved technology by an individual or farmer at a given period. On the other hand, technology diffusion is defined as "the process by which a technology is communicated through certain channels over time among the members of social systems". It signifies a group of phenomena, which suggests how technology spreads among users. It takes place at the individual level and is the mental process that starts when an individual first hears about the technology and ends with its final adoption or rejection.

Rogers (1962) summarized the four central elements of technology diffusion: (1) the technology that represents the new idea, information, practice, or object being diffused, (2) communication

channels that represent the flow of information about the new technology from technology owners to final users or farmers, and (3) the period over which a social system adopts techno. Overall, the technology diffusion process entails the gradual adoption of new technologies by a group of people or farms.

Feder *et al*. (1985) conclude that adoption can be categorized into individual or aggregate adoption. They defined individual adoption as the extent of use of new technology in long-run equilibrium when the farmer has awareness about the improved technology and its impact, whereas aggregate adoption is defined as the process of spread of technology within a community. Further, their studies distinguished technologies that are divisible and non-divisible. Divisible technology in the ways of resource utilization requires the decision procedure to involve area allocations and levels of use of the rate of application.

Therefore, adoption of improved agricultural technologies such as thinning practices of sorghum, inorganic fertilizer application on sorghum, row planting of sorghum, and sorghum ridge practice can be categorized as divisible technology, defined as farmers who tried at least one improved management practices of sorghum, and non-adopters are those who did not grow any of the improved management practices of sorghum at the study season.

Most of the theoretical studies of the adoption behavior of individual farmers use static analysis which relates the degree of adoption to the factor affecting it. This study identifies the particular cases of the temporal optimization problems of sorghum producer farmers.

Rate of Adoption

An overview of the literature shows that many researchers have studied the impact of the attributes of innovations on different social settings based on Rogers' theory (Rogers, 1995a). According to Kivlin (1998) and Fliegel and Kivlin (1966) found relative advantage and observability of results had a positive association with the rate of adoption. This result was the same as with the results of (Rubin and Smith, 1990). On the other hand, Singh *et al*. (2018) also identify the farmer's reaction to twenty-two innovations introduced to them. Therefore, he found

that relative advantage; complexity, Trailibility, and observability of results influenced the rate of adoption and have a positive correlation.

Surry (1977) investigate relative advantage and compatibility are significantly associated with the perception among potential adopters of instructional technology in high. In addition to these perceived attributes, other variables such as the type of innovation-decision, the nature of communication channels diffusing the innovation at various stages in the innovation-decision process, the nature of the social system, and the extent of change agents' promotion efforts in diffusing the innovation, affects an innovation's rate of adoption (Rogers, 1983).

Adoption vs. Diffusion

The word diffusion meaning "the stage in which the technology spreads to general use and application", while adoption meaning to "the stage in which a technology is selected to be used by an individual or an organization"(Rogers, 2003). Therefore, while the word adoption is appropriate to an individual level, diffusion can be thought of as adoption by the masses. According to Sharma and Mishra (2014), both terms are important because adoption, in the end, will generally lead to diffusion.

Diffusion vs. Innovation

"Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system"(Rogers, 1983) while "an innovation refers to an idea, practice, or object perceived as new by an individual or other unit of adoption". Recently, information technologies such as the internet, cell phones, radio are the major aspects of mass media and interpersonal channels represent have tools of diffusion (Miller, 2015).

Either farmers or other stakeholder individuals may internalize an innovation for sometimes but not organize a favorable or unfavorable attitude about it, nor have adopted or rejected it. The "newness" aspect of an innovation may be described in terms of knowledge, persuasion, or a decision to adopt (Rogers, 1983). Diffusion required exhaustive ways of communication, by which the information is concerned with new ideas. To address a common understanding,

stakeholders should create and share information that is called the communication process. From its definition, we can understand that communication is a procedure of convergence as two or more individuals interchange information to move toward each other in the meanings that they ascribe to certain events. We may consider “communication as a mutual process of convergence, rather than as a one-way, linear act in which an individual seeks to transfer a message to another” (Rogers, 1983).

2.1.3. Basic concepts of perception

An attitude is a mental or neural state of readiness, organized through experience, exerting a dynamic influence on the individual’s replied to all objects and situations to which it is related. Simply, attitude is a mined setup or a tendency to act in a particular way due to both an individual’s experience and temperature (Cantril and Allport, 1935).

Perception is almost similar to attitude but they are not the same words. Perception is the procedure by which organisms analyze, interpret and organize sensation to find a meaningful experience of the globe (Bradburn, 2010). On the other hand, a person is subjected to a situation or stimuli. The person interprets the stimuli into anything to him or her based on their experiences. However, what a person thinks or perceives may differ significantly from reality. The perception process is influenced by a person's awareness and acceptance of stimuli. Receptivity to stimuli is highly selective, and a person's previous beliefs, attitudes, motivation, and personality may limit it (Ajzen, 2005). Individuals will choose stimuli that meet their immediate requirements while ignoring those that could induce psychological distress.

According (Broadbent, 1958) addressed the concept of perceptual vigilance with his filter model. He argued that, on the one hand, due to limited capacity, a person must process information selectively, and therefore, when presented with information from two different channels, an individual’s perceptual system process only that which it believes to be most relevant. However, perceptual defense creates an internal barrier that limits the external stimuli passing through the perception process when it is not congruent with the person’s current beliefs, attitudes, motivation, etc. This is referred to as selective perception, Selective perception occurs when an

individual limits the process of external stimuli by selectively interpreting what he or she sees based on beliefs, experience, or attitudes (Sherif and Cantril, 1945).In any case, people are selective in what they perceive and tend to filter information based on the capacity to absorb new data, combined with preconceived thoughts (Jeffrey, 1985).

Perception of differences would influence decisions to adopt or reject a specific technology. Therefore, we expected, sorghum producers, farmers to receive and gather stimuli that indicate the attributes of improved sorghum management practices of sorghum are superior to local sorghum management practices. (Rogers, 1983) has categorized characteristics that may describe an innovation and individuals' perceptions, which predict their rate of adoption. Thus are a relative advantage to the current tool, compatibility with the pre-existing system, complexity or difficulty, Trailibility, and observability of its effects.

2.1.4. Adoption Attribution Theory

Attribution theory was first introduced by Heidler and Steger (1958) as "naïve psychology" to help explain the behavior of others describing ways in which people make causal explanations for their actions. Heidler and Steger conclude that people have two behavioral motives (1) the need to understand the world around them; and (2) the need to control their environment. According to (Weiner, 1988), when one tries to describe the processes of explaining events and the relating behavior, external or internal attribution can be given.

An external attribution ascribes cause to something outside of oneself, such as a force. An external attribution asserts that the events were caused by an external force. Internal attribution, on the other hand, gives causality to things within the person. The person was personally responsible for occurrences, according to an internal attribution. Finally, different attribution would determine the adoption level of agricultural technologies in different regions.

2.2. Adoption theories

Theories of adoption and diffusion

There are different types of adoption and diffusion theories. (Lauterbach, 2000) as well (Sharp *et al*., 2016) indicated that the rate at which payment systems are formulated depends largely on a struggle between rapid technological change and natural barriers to new product or service acceptance. According to (Sharp *et al*., 2016) indicated that behavioral and cognitive theories are components of adoption decision theories in agriculture. Behavioral theories are learning theories predicated on the assumption that all behavior is conditioned. According to cognitive theories, action is inspired by the unpleasant tension that occurs from jointly having two competing notions. It focuses on motivation, problem-solving, decision-making, and cognitive conditions.

Several theories have been advanced to describe consumers' acceptance of new technologies and their intention to use them. These included, but were not restricted to, the Theory of Diffusion of Innovations (DIT) (Rogers, 1995b) that started in 1960, the Theory of Task-technology fit (TTF) (Goodhue and Thompson, 1995), the Theory of Reasonable Action (TRA) (Ajzenand Fishbein, 1975), Theory of Planned Behavior (TPB) (Ajzena, 1991), Decomposed Theory of Planned Behavior, (Taylor and Todd, 1995), the Technology Acceptance Model (TAM) (Mcendoo, 1989), Final version of Technology Acceptance Model (TAM2).

(Rogers, 1995a) proposed that the theory of 'diffusion of innovation' was to establish the foundation for researching innovation acceptance and adoption. Rogers synthesized research from over 508 diffusion studies and came out with the 'diffusion of innovation' theory for the adoption of innovations among individuals and organizations. The theory explicates "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995a).

It's the procedure of the members of a social system to communicate an innovation through certain channels over time known as diffusion. The (Rogers, 1995a) diffusion of innovation theory explained that the innovation and adoption happened after going through several stages

including understanding, persuasion, decision, implementation, and confirmation that led to the development of (Rogers, 1995a) adoption, as innovators, early adopters, early majority, late majority, and laggards.

Theory of reasoned action (TRA)

Over the years, considerable attention has been paid to both academic research and communication campaigns to modify reasoned action behaviors. The TRA aims to explain volitional behaviors. It is explanatory scope excludes a wide range of behaviors such as those that are spontaneous, impulsive, habitual, the result of craving, or simply scripted or mindless (Trafimow, 2009). Such acts are excluded because they may not be performed voluntarily or because the actor may not make a conscious decision to engage in the behavior. The TRA excludes from its scope those behaviors that may require special skills, unique opportunities or resources, or the cooperation of others to be performed (Liska, 1984). One may be prevented from performing a behavior because of a skill deficit, lack of opportunity, or lack of cooperation from others and not because of a voluntary decision not to engage in the behavior (Trafimow, 2009).

Theory of Task-technology Fit (TTF)

Discounting minor differences that reflect some of the specific contexts to which TTF theory has been applied, most definitions of TTF tend to suggest that it represents the degree of matching or alignment between the capabilities of an information system and the demands of the tasks that must be performed. As such, researchers seeking to apply TTF would appear to have a sound basis for operationalizing its central construct (Elsan, 2010).

Theory of Planned Behavior (TPB):

The theory of planned behavior (TPB) has been effectively utilized to explain and predict behavior in a wide range of behavioral domains, including physical activity, drug use, recycling, and travel choices. The TPB begins with a clear explanation of the behavior of interest, including the target, the action, the context in which it occurs, and the timeframe. Each of these elements

can be defined in a variety of ways, depending on how specific or general they are. All other constructions in the theory must, however, conform to the behavior in all four elements after the behavior has been described. This is known as the compatibility concept (Ajzen, 1988). For example, to study technology acceptance, an investigator may define the behavior of interest at a low level of generality, such as **"**installing (action) a webcam monitor (target) at home (context) in the next three months (time frame)."Alternatively, the investigator may be interested in technology acceptance at a more general level and define the behavior as "buying (action) an internet-connected device (target) in the next three months (time)**"**.

It's worth noting that the target has been broadened to cover a wide range of devices rather than just a webcam and that the context has been left undefined. The behavioral definition chosen determines how the TPB's constructs are to be formulated and measured (Icek Ajzen, 1988). Behavioral beliefs are thought to induce a positive or negative attitude toward activity when taken together. In particular, the positive or negative valence of each expected consequence or experience influences overall attitude in direct proportion to the subjective likelihood that the behavior will yield the desired result (Icek Ajzen, 1988).

Expected utility theory (EUT)

The EUT explains the household chooses between risky or uncertain prospects by referring to their utility values. It states that a farmer compares the innovation with the traditional technology and adopts it if the expected improved technologies utility is greater than the expected utility of the traditional technology (Elgar, 1998). In this theory, there is Subjective Expected Utility Theory (SEUT) which is focus on uncertainty conditions, and Von Neumann-Morgenstern Theory (VNMT) in the case of a risk condition. Von Neumann and Morgenstern chose to determine the utility value of randomized strategy in a mathematically convenient way (Mongin, 1998). EUT assumes that farmers have only the objective of maximizing the expected utility of profit. However, it does not consider social pressure on farmers to adopt an innovation. The combination of EUT and TRA/TPB avoids the above-pointed restrictions. Considering both theories provide a broad and compressive view on adoption decisions.

The farmer households are influenced by the utility that they obtain as a result of making their own decision. Allying with the theory that smallholder farm households are maximizing utility (Von Neumann-Morgenstern's utility theory). The adoption decision is modeled in a random utility framework. The difference between the utility from adoption ($UTECH_i$) and non-adoption ($UTECH_i^*$) of agricultural technologies (i= 1, 2, 3, 4 represent row planting for sorghum, inorganic fertilizer for sorghum, thinning and ridge practice for sorghum, respectively) may be denoted as Ti*, such that a utility-maximizing farm household will choose to adopt a sorghum row planting, applied inorganic fertilizer on sorghum, thinning practice for sorghum, and ridge practice for sorghum, if the utility gained from adopting is greater than the utility of not adopting ($Ti^* = UTECH_i - UTECH_i^* > 0$). Since these utilities are unobservable, they can be expressed as a function of observable elements in the following latent variable model:

$Ti^* = X'\beta + Z'\alpha + \varepsilon$, $T > 0$ if $Ti^* > 0$

Where Ti* is a continuous indicator variable, represents adoption status and its level of sorghum row planting, inorganic fertilizer, thinning, and ridge practices of sorghum crop production. The status of adoption is whether the farmer applied improved management practices of sorghum production or not, while the level of adoption is measured by calculating the proportion of cultivated land covered by technologies of the total sorghum cultivated land during 2020/21 production season, and β and α are vectors of parameters to be estimated; Z and X are vectors of explanatory variables, and ε is the error term. The Expected Utility Theory is similar to the study (Adoption improved management practices of sorghum).

The Social Cognitive Theory

Neal Miller and John Dollard first introduced the social cognitive theory in 1941. The social learning theory is another name for this approach. This theory focuses on the cognitive, behavioral, individual, and contextual aspects that influence people's motivation and conduct. There is no single reason that can determine our thoughts or behaviors. Social cognitive theory is also referred to as a theory of theories or a Metatheory. Social Cognitive Theory (SCT) describes the influence of individual experiences, the actions of others, and environmental factors on individual health behaviors (Swearer *et al*., 2014). SCT provides opportunities for social support

through instilling expectations, self-efficacy and using observational learning and other reinforcements to achieve behavior change (Miller and Dollard, 1941). Self-efficacy, behavioral capability, expectancies, self-control, observational learning, and reinforcement are SCT components associated to individual behavior change. A person's ability to succeed is determined by their perception of their ability to attain goals; these perceptions influence motivation and performance. This is referred to as self-efficacy. Self-efficacy is measured in two scales magnitude and strength and four main factors help us create our self-efficacy ideas of what we can succeed at, and they are: 1) performance outcomes, 2) vicarious experiences, 3) verbal persuasion and 4) physiological feedback (Miller and Dollard, 1941). Everyday life is increasingly regulated by complex technologies that most people neither understand nor believe they can do much to influence (Bandura, 2001). The very technologies they create to control their life environment paradoxically can become a constraining force that, in turn, controls how they think and behave (Bandura, 2001).

Technology Acceptance Model (TAM2)

By (Venkatesh and Davis, 2000), TAM3 by (Venkateshand Bala, 2008), and UTAUT by (Venkatesh *et al*., 2003) were not selected since the situation was for products to be implemented in the marketplace and taken into consideration of subjective norms that included society not required for this study involving the novelty technology of single platform E-payment System. (Mcendoo, 1989) explained that social norms scales had a very poor psychometric standpoint, and might not exert any influence on consumers' behavior intention, especially when information system application like single platform E-payment System was fairly personal while individual usage was voluntary. UTAUT is an extension of TAM2 and TAM3 is an extension of TAM2 that includes social influence, therefore they will not be used in this study based on the social norm. TAM2, TAM3, and UTAUT use moderators but the present study only focuses on the factors and consumers' intention to use a single platform E-payment System. Furthermore, TAM2, TAM3, and UTAUT did not include direct relations studies. Therefore, TAM2, TAM3, and UTAUT were not favorable to study the novelty technology of single platform E-payment System.

2.3. Adoption studies in Ethiopia

New technology's contribution to economic growth can only be recognized when and if it is broadly disseminated and utilized. Diffusion is the outcome of a succession of individual decisions, which are frequently the consequence of a trade-off between the risk of discovery and the risk of accepting it. Because the majority of the population of developing countries depends on agricultural production for a living, and because new technology provides the opportunity to significantly increase production and income, adoption of technological innovations in agriculture has attracted considerable attention among development economists (Rogers, 2003).

An individual recognizes a new concept, practice, or thing as innovation. The emphasis is on the idea's perception; the innovation just needs to be "new" to the individual adopter. This demonstrates that adoption is a mental process that begins with first hearing about an invention and ends with deciding to fully implement the new concept (Rogers and Shoemaker, 1971). According to Feder and Zilberman, (1985) argued that the sociological explanation of option is usually mostly indicated for ‘rigorous theoretical and empirical analyses due to their inaccurate and limited to differences individual or farm level adoption from aggregate adoption. The term adoption can refer to a personal act, a legal process, or a social service (Cole and Donely, 1990). Adoption arouses controversy across the political spectrum, challenging neat diversion between left and right and demanding new ways of thinking from across the human sciences. Difficult to define, adoption is best seen as a set of loosely related and time-bound practices- social and legal, also political and economic-whose meanings shift they are contested. Critical adoption studies have come into being as the field of cultural critique and scholarly debate that captures and finds meaning in these controversies, and, in so doing, poses fundamental and constructive challenges to existing modes of thought and of scholarly inquiry.

2.4. Empirical studies on factors influencing adoption

While many studies have been conducted on various aspects of adoption, researchers in the social sciences agree that important research in the area of adoption and adoptive families is still lacking (Krusiewicz, and Wood, 2001). Several agricultural technology adoption studies have been studied on a specific area at a particular technology. The obvious determinants of new

technology adoption are the benefits received by the user and the costs of adoption. In many cases, these benefits are simply the difference in profits when firm shifts from older technology to newer. Accordingly, too (Berihun Kassa *et al*., 2014), farm size, distance to the main market, farmer perception of improved varieties, active family labor force, and ox significantly influence the adoption of seed. Other studies conducted by (Tewodros Tefera *et al*., 2016) found that proportion of male-headed households, education level of the household head, participation in participatory variety selection, distance to the nearest agricultural office, contact with government extension agent, participation in technology transfer, own mobile phone, own mobile radio were the factors that affect the adoption of improved pigeon pea varieties.

As reported by Teame Hailemariam, (2011) also found that education status of the household, adult labor, family size, plot number, average plot distance, market distance were the factors determining fertilizer adoption of the peasant farm sector. According to Bekele Wegi, (2020) concluded that gender of the hushed head, age of the household head, education level of the household head, farm size, livestock holding, access to extension service, access to credit, membership to cooperatives, distance to the market were the determinant of agricultural technology adoption in Ethiopia, using meta-analysis. Other studies studied by Asfaw and Neka (2017) found that age of the household head, sex of the household head, education status of the household head, distance from homestead, off-farm activity, access to extension service, and access to training service were the factors affecting adoption of soil and water conservation practices.

Both abroad and in Ethiopia, there is literature on the adoption of high-improved crop and livestock varieties, as well as technology management. Farmers' adoption decisions are influenced by a variety of factors, including demographic, economic, social and networking, communication and information, behavioral, and institutional factors, according to studies.

Demographic characteristics

Demographic characteristics are the most important variables that influence technology adoption decisions. Respondent sex, age of the respondent, education level of the household head, and active family labors are the major factors that affect improved technology adoption. In

developing countries due to cultural and social grounds, women have less access to institutional, information, and communication services. Most studies showed that the relationship household education status to technology adoption, positive relationship with technology adoption in favor of educated households. According to Simtowe *et al*. (2011) conducted on determinants of agricultural technology adoption, the education level of the household headed was more adopters of technology than a non-educated household headed. Simtowe *et al*. (2011) reported that education status was not influenced by inorganic fertilizer adoption on sesame productivity. In addition, according to (Petros Admasu *et al*., 2014) study conducted on the adoption of agricultural technologies on the income of and they reported that education status was not a significant difference between adopters and non-adopters. (Berihun Kassa *et al*., 2014) studied that age and gender of the household head have no significant difference on the agricultural technology adoption. According to (Almaz Giziew and Begashaw Mebrate, 2019) on the study determinants of the role of gender on the adoption of row planting of tef indicated that there was a significant difference in sex and education between adopters and non-adopters of the household heads. The other studies conducted by Egge *et al*., (2010) reported that age and farming experience have a significant effect on the adoption of improved sorghum varieties. According to Teame Hailemariam (2011), the total family size of the household has a positive effect on fertilizer adoption of the peasant farm sector.

Economic Variables

Economic variables are important factors to being adopters of agricultural technologies. This variable includes total land holding, non-farm income, farm income, and total livestock holding. According to Teame Hailemariam (2011), farm size and oxen could affect positively the fertilizer on sesame adoption of the peasant farmers. Other studies by Solomon *et al*. (2011) reported farm size, and oxen have a positive effect on agricultural technology adoption, seed access, and constraints. Kebebe (2015) found that total landholding area, and livestock holding influence positively and significantly the adoption in smallholder livestock production systems. Farm income is one important variable for adoption decisions. The amount of household income collecting from the sale of crops and animals, after household expenditure is met helps to purchase agricultural inputs. Accordingly, Mesfin Fenta (2017) reported that household income

had a positive and significant effect on technology adoption decisions. However, the study of (Simtowe *et al*., 2011) reported that income has no significant effect on technology adoption.

Livestock holding is the main indicator of households' wealth position. Livestock is also an important source of generating income that helps to afford agricultural inputs. Mostly, it has a positive association with technology adoption decisions. According to, (Simtowe *et al*., 2011), (Russakovsky *et al*., 2015), and (Silamlak Birhanu and Faris Hailu, 2021) have reported that livestock ownership had a positive and significant result for technology adoption decisions than those who had not livestock. However, (Yitayal Abebe and Adam Bekele, 2014) indicated that Livestock ownership had a significant effect on delaying technology adoption.

Institution and infrastructural

Institutional and infrastructural variables are important factors that help to adopt affect agricultural technologies. Access to credit is very important for technology adoption. Capital is one of the best important inputs for agricultural production. According to (Negera Eba and Getachew Bashargo, 2014), (Berihun Kassa *et al* ., 2014), and (Ogada, 2014) found that credit had a positive and significant effect on household head technology adoption decisions. Even if, (Simtowe *et al*., 2011) concluded that access to credit had no significant influence on the adoption of technology. Distance to the main market, distance to main road and distance to the agricultural office, distance to cooperative, and distance to primary cooperatives are usually inversely affected for technology adoption decision. (Berihun Kassa *et al*., 2014), (Negera Eba and Getachew Bashargo, 2014), (Tewodros Tefera *et al*., 2016), Yitayal Abebe and Adam Bekele (2014) indicated in their study that, these variables had a negative and significant effect on the decision of technology adoption for the household head.

Household asset variables

Household asset factors are one category of the variables which are mostly related to farmers' adoption behavior. These are radio, mobile, television; oxen plow set, grain mill, carts, and other household materials. Extension service is one of the most important factors for technology adoption. Negera Eba and Getachew Bashargo (2014), Sahin *et al*. (2014) Yitayal Abebe and

Adam Bekele (2014), Felix *et al*. (2018) reported that extension service was a positive and significant factor for technology adoption decisions. However, (Abubakar *et al*., 2014) conducted on the determinants of farmer adoption of improved peanut varieties and their impact on farm income indicated that extension service had not a significant difference on technology adoption. Radio and mobile are important tools for technology adoption and diffusion. Berihun Kassa *et al*. (2014) found that radio and mobile ownership had a positive and significant influence on technology adoption. However, Simtowe *et al*. (2011) indicated that radio and TV had not significantly affected technology adoption decisions.

The availability of extension events is very necessary for the decision of technology adoption. Simtowe *et al*. (2011) showed a significant effect of this variable on technology adoption. Perception with the way the attribute of innovation is perceived and the respondent's perception of the technology attribute. According to (Akalu Teshome *et al*., 2016) on the study of household-level determinants of soil and water conservation adoption phases indicated that farmers' perception of soil erosion had a significant effect on the adoption of soil and water conservation practices.

2.5. **Farmers' Perception towards Improved Technologies**

The importance of commodity–attribute perception has long interested social scientists investigating agricultural technology adoption decisions. Anthropologists and sociologists have played a lead role in this area and have argued, using qualitative methods, that farmer's subjective assessment of agricultural technologies influences and option behavior (Fliegel and Kivlin, 1966b). Economists have been slow to investigate this topic. However, because most previous economists' studies on technology adoption (Adesina and Baidu 1995) lacked access to direct observations of farmers' perceptions, it was impossible to test the hypothesis that perceptions of technology attribute influence adoption decisions directly and quantitatively. Instead, variables that affect farmers' access to information, and hence their perception formation, example extension, education, media exposure, etc., are typically used in economic model of the determinants of adoption decision (Feder and Jossang, 1985; Shakya, and Flinn, 1985; Yohannes *et al*, 1990; Adesina, and Forson, 1995). Economists studying consumer

demand, on the other hand, have accumulated a substantial amount of evidence demonstrating that consumers have subjective preferences for product characteristics and that their demand for the product is significantly influenced by their perceptions of the product's attributes (Jonesand Moore, 1993).

Considering and having a solution for farers' issue about technology attributes affects the success of agricultural technologies. It is known that the participation of farmers in research is very crucial (Monu, 1997). "The concept farming system research and extension explicitly recognize the value of the farmers' experience and their traditional experimentation as inputs into strategies for improving the productivity of existing farming systems"(Garrity *et al*., 2012). From the nature of agricultural technologies, there is no single factor that determines the adoption behavior of farmers (Mawusi, 2004).

The Farmer's perception of technology-specific attributes was measured by interviewed producers to list out his/her opinion as to the level, strongly agree, agree, neutral, disagree, and strongly disagree on perception statements presented to the farmer (Timu *et al*., 2014). Silamlak Birhanu and Faris Hailu (2021) conducted farmers' perception about the use of sorghum, and they identified the attributes of Famers such as color for market demand, food quality, land degradation, reduction land soil fertility, drought, late maturity type, Parasitic weeds, and bird damage.

Plant growths, grain yield increment, biomass yield increment, a maturity date of the plant, easy weed and pest management, controlling runoff, and help to improve the soil fertility status were the major parameters to adopt improved management practices of sorghum in the Gondar Zuria district.

2.6. Analytical Framework of the Study

Many kinds of literature, practical experiences, theories, and observations of reality have shown that one factor may facilitate the adoption of technology in one area and time. However, it also may hinder in another situation. Therefore, it is difficult to develop a specific and unified adoption model in the technology adoption process because of the economic, social, and

networking, behavioral and infrastructure variation of different areas, and also various natures of determinant factors. This study is based on assumption that several factors influence the adoption of improved management practices of sorghum. These factors are demographic, economic, agricultural extension service, social and networking, information and communication, institutional and behavioral variables.

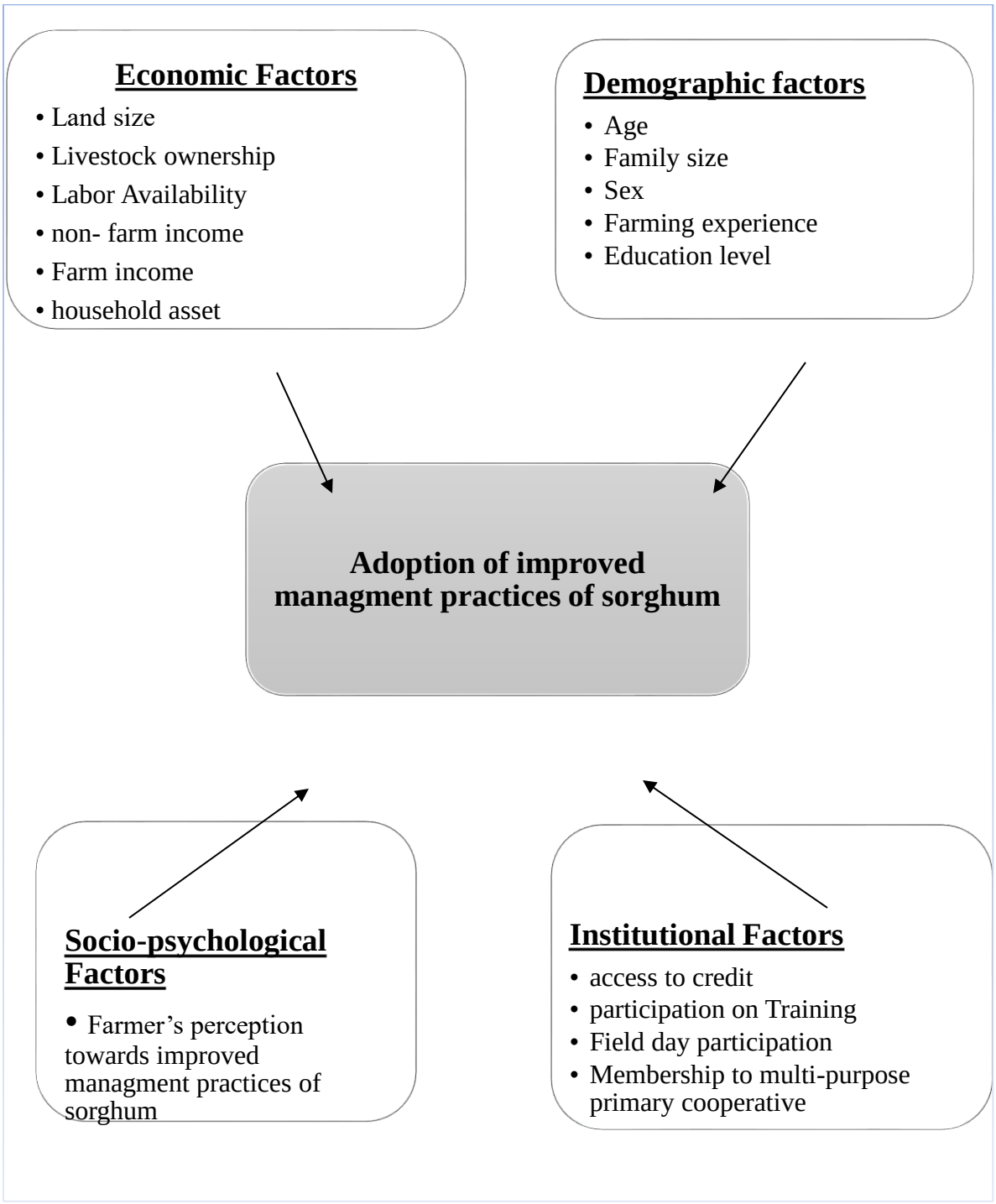

Figure 2.2. Conceptual Framework

Source: Own, based on literature review, 2021

Chapter 3: RESEARCH METHODOLOGY

This chapter explains how the research was conducted. It includes; the description of the study area, sampling procedure, and sample size determination, methods of data collection, methods of data analysis, and dependent and independent variables and hypotheses.

3.1. Description of the Study Area

Central Gondar administrative zone is one of the Zones of Amhara regional state, Ethiopia. This zone has the potential for agriculture both crop production and livestock rearing. The study area, Gondar Zuria district is one of the districts in the Central Gondar Zone. The study area is Gondar Zuria district, which is located 40 km away from Gondar town. The district is located East of Dembia, West of Belesa district, the North of Gondar town, and South of Libo Kemkem district. The area has uni-modal rainfall with an annual rainfall that ranges from 641mm to 1678 mm with a mean of 1052 mm rainfall. The area has an annual mean and minimum temperature of 10.6°C while the mean maximum temperature is 32°C.

The population is becoming increasing from time to time while the natural resource is limited and in contrast, the demand of the people is becoming increase. In this district, mixed farming is common, both crop cultivating and livestock rearing have been practiced by all households. From crop-cultivated teff, chickpea, sorghum, and wheat are commonly produced (GZAO, 2021).

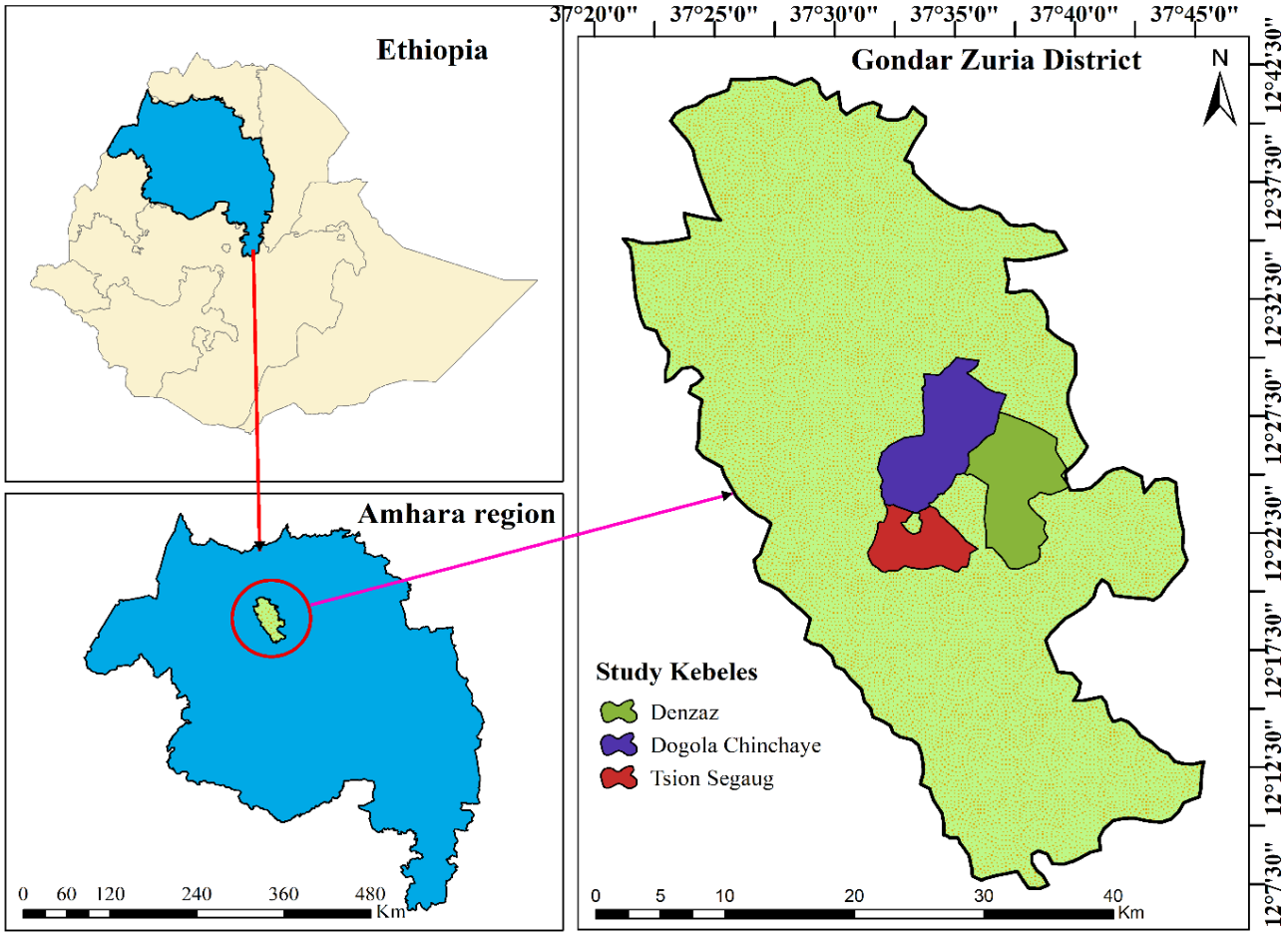

Figure 3.3 . Location map of the study area (Atikilt Abera, 2021)

3.2. Sample size determination and Sampling procedure

Amhara agricultural research institute, Gondar agricultural research center in collaboration with the Agricultural growth program–II, and ICARDA have been working in promoting improved management practices of sorghum in central Gondar zone, Gondar Zuria district. Moreover, both biological and social science research teams have been working on improved management practices of sorghum promotion to popularize the technology for the study district. Likewise, the researcher has worked in transferring different agricultural technologies and mostly on sorghum. Therefore, Gondar Zuria district was selected based on the practical experience of the researcher in the study area and previous research intervention of Gondar agricultural research center. Gondar Zuria district is one of the major intervention areas for GARC to technology generation, promotion, and multiplication. In the technology promotion process, improved management

practices of sorghum are one of the prior technologies in the study area. GARC has promoted sorghum improved management technology using demonstration and pre-scaling- up (as a clustering approach). So, based on the above rationale, Gondar Zuria district was selected purposively for improved management practices of sorghum adoption study. A three-stage procedure was employed to select sample households for this study. Accordingly, sorghum-producing kebeles have been identified for selecting sample kebeles. Then, four kebeles were selected randomly. Finally, sample respondents were selected using a systematic sampling technique. The main reason for using this type of sampling method is: (1) the population in these kebeles are homogenous in terms of socio-economic characteristics, institutional setup, and livelihood structure in many ways and farming practices they followed. (2) Lists of the household heads (sample frame) are available at kebele leaders and DAs because of its importance for the administrative and monitoring purpose. Therefore, in the presence of sample frame and relative homogeneity in the population, using a simple random sampling method was more appropriate than other sampling methods. The number of respondents in each kebele has been determined by proportionate to size.

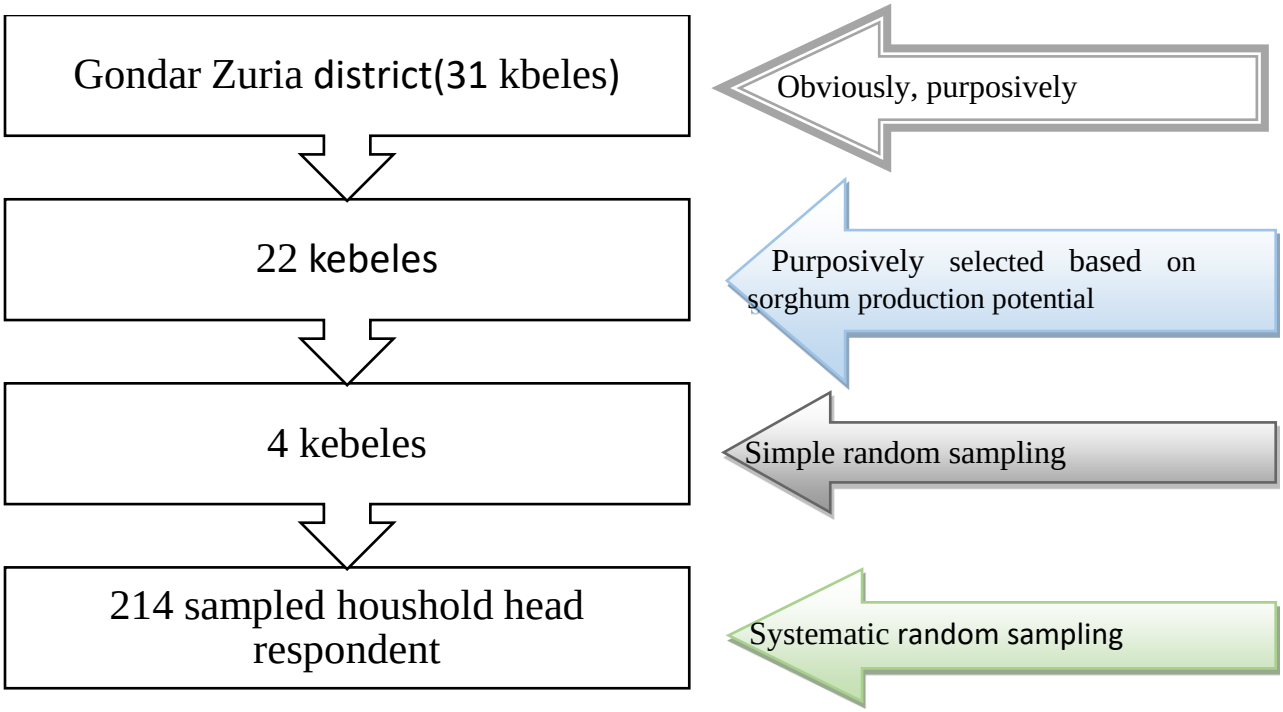

Figure 3.4. Graphical representation sample procedure

As shown in figure 3.4 above, the study woreda was selected purposively since it was an intervention area for the ICARDA project, GARC, and AGP-II project. The Woreda has 31 total kebeles and from this, 22 kebeles were selected based on the sorghum production potential. From these kebeles, 4 kebeles were selected using a simple random sampling technique to avoid selection bias. Finally, 214 sampled household head respondents were selected by using a systematic sampling technique from four kebeles.

3.3. Sample Size Determination

There are several methods to determining 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 the sample size. All these methods to determining sample size have assumed that a simple random sample is the sampling design. Here a complex- design, e.g., stratified random samples, must take into account the variances of sub-populations, strata, or clusters (Bartlett II *et al*., 2001).

Sorghum growers in the selected kebeles were used as the sampling frame and the sampling units was being the household heads. The sample size for this study was determined based on the following formula given by Yamane (1967) as follows;

$$n = \frac{N}{1+N(e)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation number (1)}$$

Where n is the sample size for the study, N is the population of interest (sorghum grower farmers in the production year) which is 2092, e is the precision level which will be 0.07 in this study due to the reality that the population in the study area is relatively homogeneous in the socio-economic setup. Based on the above formula 214 sample respondents were selected randomly. For this study a total of 214 sampled respondents were selected and to replace the absence of sample members, 10 % of the sampled respondents were used (Israel, 2003). The sample size for each kebele has been determined based on their proportion to the total share of households residing in each kebele.

Table 3.1. Distribution of sample respondents among selected kebeles

	Name	Number of Growers in 2011/12 E.C	Number of Samples selected (Using PPS)	Share (%)
1	Denzaz	591	61	28.50
2	Chinchaye	284	29	13.55
3	Degola	587	60	28.04
4	Tsion	630	64	29.91
Total		**2092**	**214**	**100**

Source: Gondar Zuria district Agriculture office, 2021

3.4. Methods of data collection

To meet the objectives of the study, a cross-sectional survey incorporating both qualitative and quantitative by applying a structured interview schedule was employed. Both primary and secondary data sources were used. The primary data were collected directly from sorghum grower farmers through structured interviews and focus group discussion while secondary data were collected from the published and unpublished data sources. GARC, Central Gondar zone, and Gondar Zuria district office of agriculture were the source of the document.

A formal survey was organized and enumerators collected data from selected sampled respondent household heads by a structured interview schedule. The training was delivered for the data enumerator to have the same ways of interview. Before getting into the formal data collection pre -a test was conducted by trained enumerators to have a common understanding of the data collection instrument and detect other errors.

Finally, researchers of the Gondar agricultural research center administered and delivered to 214 household heads that were randomly selected from 4 kebeles. Those kebeles were Chincahye, Tsion-segaji, and Degola and Das-denzaz.

3.5. Methods of Data Analysis

3.5.1. Descriptive Analysis

To explain the overall sorghum production level concerning the desired characteristics, descriptive statistics such as mean, standard deviation, and percentages were used. Inferential tests such as (t-test for continuous variables and chi-square ($\chi 2$) test for dummy/discrete variables were employed to compare mean/association of socioeconomic characteristics between improved management practices of sorghum adopters and non-adopters. One-way ANOVA was employed for testing the overall mean differences among improved management practices of sorghum adoption categories.

Farmer positive Perception towards the improved management practices of sorghum

Farmers' knowledge about sorghum improved management technologies (row planting, fertilizer application, thinning, and ridging practices) and their attributes are important for the adoption of technologies. Farmer's positive perceptions towards improved management practices of sorghum were analyzed using the Relative Importance Index (RII) which calculated as follows;

$$RII = \frac{\sum w}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \ldots\ldots\ldots \text{ equation number (2)}$$

Where w is the weighting given to each factor by the respondent, ranging from 1 to 5. For instance, n1= number of respondents for little important, n2= number of respondents for some important, n3= number of respondents for quite important, n4= number of respondents for important, n5=number of respondents for very important. A is the highest weight (i.e. 5 for this study) and N is the total number of respondents. The relative importance index (RII) ranges from 0 to 1 (Le and Tam, 2007). All respondents gave the score for each criterion for each improved management practice of sorghum (row planting, thinning practice, ridge practice, and inorganic fertilizer usage). The score was from 1 to 5, 1 is the lowest value, and 5 is the highest score.

The reliability test of the goodness of attributes specified in the study area for the Likert scale method of analysis was conducted.

Levels of adoption of improved management practices of sorghum

In order to estimate the level of adoption of improved management practices of sorghum (row planting, Inorganic fertilizer, thinning practice, and ridge practice), adoption index was employed using the following formula.

$$AIi = \sum \left(\frac{Ari}{AT\ sor} + \frac{Afi}{AT\ sor} + \frac{Athinn\ i}{AT\ sor} + \frac{Aridge\ i}{AT\ sor} \right) / NP$$

Where: AIi= Adoption index

Ari= Area under row planting ith farmer

AT sor= Total area allocated for sorghum production ith farmer

Afi= inorganic fertilizer applied by ith fNParmer

Athinn i = Area allocated for thinning practice ith farmer

Aridge I = Area allocated for ridge practice ith farmer

NP = number of practices

3.5.2. Econometrics Analysis and Model Specification

Adoption Status of Improved management practices of Sorghum

Different econometrics models have been used to study the major factors affecting agricultural technologies at different times at different places. The objective of the specific study determines what would be the econometrics model. Usually, a researcher has gone data collection without the information about the status of the adopter and non-adopters in the study of his/her study area. Even if there are a lot of econometric models used to identify factors affecting agricultural technologies, the multivariate probit (MVP) model is the one.

The MVP is a binary response regression model used to estimate both observed and unobserved influence on dependent variables by several independent variables simultaneously, which permits error terms to correlate freely (Gibbons and Hedeker, 2000). A multivariate probit

(MVP) model was employed to analyze the interdependent decision of improved management practices of sorghum (row planting, inorganic fertilizer application, thinning, and ridge practice) by farmers in the study district. Improved management practices are multivariate by their property. Therefore, considering the interaction of improved management practices of sorghum multivariate probit model was employed to analyze those variables. Farmers would indeed apply improved management practices to obtain a high grain yield instead of applying a single improved management practice. In opposite to the multivariate probit model, univariate probit models analysis leaves the potential correlation among the unobserved disturbances in the improved management practice equations as well as the relationships between the improved management practices of sorghum.

The multivariate probit econometric model is specified by a set of binary dependent variables Y*ij, as follows;

$Y^*_{ji}=X_{ji}\hat{\beta}+\varepsilon_{ij}$ $j= 1\ldots, m$ and …….. equation number (3)

$Y_{ji}=\begin{cases}1 \text{ if} Y*ji>0\\ 0 \text{ otherwise}\end{cases}$ …….. …… equation number (4)

Where;

Y^*_{ij} for j=1,2,…..m represents unobserved latent variables of the improved management practices of sorghum j decision by farmer i, X is a matrix of independent variables, β is a vector of parameters estimated, εij are error terms. Error terms have a standard normal distribution with mean vector zero and a covariance matrix with diagonal elements equal to 1.

The dependent variables in the model were row planting, inorganic fertilizer, thinning, and ridge practice. The explanatory variables were identified as family size, age of respondent, respondent sex, educational level of the respondent, landholding, credit access, multi-purpose cooperative membership, farm income, non-farm income, training participation, field day participation, labor market access, household asset, and livestock holding (TLU).

3.6. Definition of variables and hypotheses

I. Dependent variable

Adoption Status: This variable describes the farmers whether they are adopters or non-adopters of improved management practices of sorghum in the Gondar Zuria district. In equation 2 the multivariate probit econometrics model estimates either adopt or not adopt. On the other hand, it identifies factors affecting the adoption behavior of sorghum producer farmers in the study area.

Table 3. 1. Adoption of improved management practices of sorghum and their indicators

Adoption status	Indicators
Non-adopter	Farmers who have not used improved management practices of sorghum in the survey year of 2020/2021 production season
Adopter	Farmers who have used improved management practices of sorghum in the survey year of 2020/2021 production season

The following independent variables were hypothesized that affect the adoption level of improved management practices of sorghum in the study district.

Adoption index: Measures the level of adoption at the time of the survey. It is used in the case of the study of multiple practices to measure adoption level. Adoption studies by Mesfin Fenta (2017), and (Negussie Siyum, 2019) used the adoption index to measure the level of adoption. Therefore, the adoption level of improved management practices of sorghum was measured using the adoption index for this study.

II. Explanatory variables

For this study, explanatory variables were used based on different kinds of literature.

Age of household head: This is a continuous explanatory variable that is measured by a whole number of years. Younger farmers have low farming experience in crop production than older farmers. Even though, when the age of the household head increases, it does not mean that they are technology accepters. Therefore, it is impossible to specify the sign of the factor on the adoption of technologies (Berihun Kassa *et al*., 2014; Akalu Teshome *et al*., 2016; Mesfin Fenta, 2017).

Household head sex: sex is used as a practices dummy variable. The sex difference is the major factor expected to affect the adoption of new or technologies. This is because of different social structures at different times at different places. The expected household head sex sign is negative. Most of the time male-headed household farmers are high adopters of agricultural technologies or improved practices than female-headed household farmers. Even though male-headed farmers have more information exposure, training access, field day participation, and access to credit, it does not give a guarantee to be high adopters of technologies than female-headed households. But the nature of the technology determines who is more adopter these help greater access to get information. Studies were done by Ermias Tesfaye (2013) Girma Gezimu (2019), Gedefaw Abebe and Sisay Debebe (2019), Menasbo Gebru (2021), found female-headed farmers were more adopters than male-headed farmers.

Household head educational status: is used as a dummy variable and educated household head of the family can analyze and use relevant information to sorghum improved management practices adoption. Therefore, the household head's educational status is expected to affect the probability of adopting sorghum improved management practices positively. Studies conducted by Mesfin Fenta (2017), (Negussie Siyum, 2019), and Susie Teshome, and Bosena Tegegne (2020) found the educational status of the household has positive and significant effects on technologies.

Total family size: The Number of individuals indoors the family. Farmers who have large family sizes may have the probability of much active labor force. Therefore, large family sizes can easily be performing agricultural activities. The study conducted by Negera Eba and Getachew Bashargo (2014) found large family sizes have the probability of technology adoption and positive association.

Farming experience: It is the number of years of experience of the household head. Long years of sorghum production experience have been a good decision. It implies, hypothesized that more farming experience is more likelihood adopting improved management practices of sorghum. According to Negera Eba and Getachew Bashargo (2014), farmers with more farm experience are more adopters of agricultural technologies.

Landholding: Landholding was measured by hectare. It is a proxy for wealth and the social status of the household head in the community. Even though households who owned small size of land considering as low social and economic status in the community but it does not mean that they are low adopters of agricultural technologies. Households who owned a small size of land have the probability of adopting improved management of sorghum than large land-owned households. Studies conducted by Teame Hailemariam (2011), Ermias Tesfaye (2013), Berihun Kassa (2014), Jafer Mume and Aman Kemal (2014), and Menasbo Gebru (2021) found a negative association between landholding and agricultural technologies.

Livestock ownership: It is measured in TLU. Livestock holding is hypothesized to be positively associated with the adoption of improved management practices of sorghum because it serves as an indicator for wealth status (Simtowe *et al*., 2011; Chilot Yirga and Hassan, 2013; Ermias Tesfaye, 2013; Mesfin Fenta, 2017; Najib, 2019; Nigussie Siyum, 2019).

Access to credit: it is measured in terms of whether respondents have got any form of credit for agricultural purposes or not access at the time of the study. Financial constraints are difficult to attain maximum production and adopt new technologies. It is a dummy variable and expected that credit has a positive association adopting improved management practices of sorghum (Berihun Kassa *et al* ., 2014; Afework Hagos and Lemma Zemedu, 2015; Najib, 2019).

Multi-purpose cooperative membership: Household participates as membership in multi-purpose primary cooperative frequently more likely to be aware of new technologies. Therefore, it is hypothesized that those farmers who participate in some cooperative organization as a member more frequently participate are more likely to adopt improved management practices of sorghum (Solomon Asfaw *et al*., 2011).

Farm income: It refers to the total annual income of the family from the sale of crops, livestock and livestock products after household consumption. This is to be the main source of capital for purchasing agricultural inputs. Thus, households with a relatively higher level of farm income are more likely to purchase or exchange improved technologies. It is measured by the amount of Ethiopian birr obtain from the sale of farm products (Afework Hagos and Lemma Zemedu, 2015).

Non-farm income: The respondent farmers are either involved in non-farm activities or not. In this study, a non-farm activity includes petty trade, livestock trading, charcoal making, salary employment, and remittances. It is hypothesized that participating in non-farm income positively influences the adoption of improved management practices of sorghum. This working definition was similar by Miah, *et al*. (2016), Muhammed Shako *et al*. (2020), Susie Teshome, and Bosena Tegegne (2020).

Training Participation: It is the household head participation in organized training events: Households head participation on how many times in the last 12 months. According to (Hadush Hagos *et al*., 2018) categorize the association between training access and adoption of rice variety.

Field day participation: It is the household head participation on organized field day events: Households head participation on how many times in the last 12 months. The study by Hadush Hagos *et al*. (2018) categorizes the association between field day and the adoption of rice variety.

Labor market access: It is the labor availability on the local market, in the study district. The household head is either accessible labor or not on a nearby market. Access to the labor market positively affects the improved practices. A study conducted by Mahdi Egge *et al*. (2010), Negese Tamirat *et al*. (2017), Almaz Giziew and Begashaw Mebrate (2019), and Menasbo Gebru Tesfaye (2020).

Household Asset: it includes the scotch cart, mule cart, oxen plow set, mobile, radio, television, corrugated iron roof sheet, grain mill. All the sum of this asset by calculating the current market price is being a household asset. The household asset is measured by Ethiopian birr. It is hypothesized household asset has a positive influence on technology adoption. Similar studies by Mahdi Egge *et al*. (2010), Negese Tamirat *et al*. (2017), and Menasbo Gebru Tesfaye (2020).

Perception towards improved practices: for this study, to evaluate the perception of farmers toward improved management practices of sorghum, a relative importance index was developed.

Each management practice was evaluated by different attributes, the score of 1 is low preferred, and 5 was a high preference. A better perception of the household head has positive influences on technology adoption (Akalu Teshome *et al*., 2016; Mesfin Fenta, 2017; Negussie Siyum, 2019; Susie Teshome and Bosena Tegegne, 2020).

Improved management practices are row planting, thinning practices, inorganic fertilizer recommendations (Urea and NPS) and ridge practices.

Table 3.3. Operational definition of explanatory variables

No	Variable name	Operational definition	Data type	Exp. sign
1	Age	A household head age measure in years	continuous	+/-
2	Educational status	1 if a household head is literate; 0 otherwise	Dummy	+
3	Sex	1 if a household head sex is male; 0 otherwise	Dummy	+/-
4	Farming experience	Farm experience of the household head	Continuous	+
5	Family size	Total family size of the household	continuous	+
6	Landholding	The household ownership of land in ha	Continuous	+
7	Livestock holding	Total Livestock owned by the household (in TLU)	Continuous	+
8	Access to credit	1 if household access to credit; 0 otherwise	Dummy	+
9	Coop. membership	1 if a household head member of the cooperative; 0 otherwise	Dummy	+
10	Farm income	Farm income Amount of farm income in Ethiopian birr was got by a household.	continuous	+
11	Non-farm income	1 if a household involved in non-farm income; 0 otherwise	dummy	+/-
12	Training Participation	Households participated in training participation	Continuous	+
13	Labor market access	1 if household access the labor market; 0 otherwise	Dummy	+
14	Household asset	Amount of household assets own in Ethiopian birr by an asset	Continuous	+
15	Field day	Households participated in training participation	Continuous	+

Chapter 4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

4.1.1. Demographic characteristics

Demographic characteristics include age, education level, respondent sex, family size, and farming experience. As indicated in Table 4.4, from the total respondents, 71.96 % were male-headed. Regarding educational status, 26.17 % of respondents were literate while 73.85% were illiterate. The average age of the sampled respondent was 45.11 years with a standard deviation of 11.55. The minimum age was 22 years while the maximum age is 68 years. It indicates most of the sampled respondent is active labor force (EDHS, 2016) . The average total family size of the household was 5.64 and the maximum total family size of the household was 12 while the minimum number of family size was 2 years. Based on the sampled respondent household heads interviewed, the average farming experience was 23.23 years and the minimum farming experience was 3 years while the maximum farming experience was 46 years.

Table 4.4. Descriptive statistics of the demographic characteristics

Variable	Obs. (n)	Total		Min.	Max.
		Freq/mean	Percent/SD		
Sex (Male)	214	154	71.96		
Education (Literate)	214	56	26.17		
Age (years)	214	45.11	11	22	68
Total family size (#)	214	5.64	1.76	2	12
Farming Experience	214	23.23	10.44	3	46

Note: variables in parenthesis are mean and standard deviation
Source: Computed from 2021 Survey in Gondar Zuria district.

4.1.2. Communication and extension method characteristics

Farmers who have access to mobile, radio, and television have better exposure to information about the farming practice and market information. As shown in Table 4.5: from the total

sample, 78 % of the respondents were mobile users while 22% were not mobile users. The other communication device was radio, and from the sampled household 20 % had radio while 80% of the sampled household had no radio. In addition, farmers need to watch practical practice in visual and television is relevant for this purpose. From the total sampled respondents, 2.8 % were television owners while the other respondents were not television owners. Field day, training, and on-farm demonstration are important ways of communication to promoting new agricultural technologies. Field day, training, and on-farm demonstration can help farmers enable to evaluate the improved varieties, management practices that are new for them. From the sampled household head-interviewed about 39 % were access training on sorghum-improved management practices, and 52 % were invited on field day. Both training and field day in either individual or in-group is very essential to transfer new technology or to give technical support for farmers. In this regard, extension providers have contacted sorghum producer farmers in the form of training and field days. As indicated in Table 4.5 below, 39.71% of adopters owned radio while 9.59 of non-adopters owned a radio.

Table 4.5. Communication and extension service characteristics

Variable	Obs.(#)	Frequency (Yes)	Percent (Yes)	Adopter owned (%) (Yes)	Non-adopter Owned (%) (Yes)
Radio ownership	214	43	20.09	39.71	9.59
Mobile ownership	214	167	78.04	45.59	54.79
Television ownership	214	6	2.80	1.47	3.42
Field day participation	214	112	47.66		
Training access	214	84	39.25		

Source: Computed from 2021 Survey in Gondar Zuria district

4.1.3. Social capital variables

Social networking and membership are important factors for rural communities to exchange information. In the study district case, primary multi-purpose cooperatives were identified as the main types of social networking variables. As indicated in Table 4.6, from the total respondents

about 57 % were members of primary multi-purpose cooperatives while about 43 % were non-members of the primary cooperatives.

Table 4.6. Membership of the household for the formal organization

Variables	Obs. (#)	Total	
		Frequency (Yes)	Percent (Yes)
Multi-purpose cooperative	214	122	57.01

Source: Computed from 2021 Survey in Gondar Zuria district

4.1.4. Wealth indicator variables

Wealth characteristics comprise livestock holding, physical asset, farm income, non-farm income, and landholding, are the main indicator of the wealth level of the household in Gondar Zuria district. In the study district, most of the sampled respondents have practiced both livestock rearing and crop farming. Livestock farming is the major supporter of crop farming, for traction plowing power, for improving soil fertility, for trampling. It is important for human nutrition and helps to generate income. As shown in Table 4.7: on average, the livestock holding in Tropical Livestock Unit (TLU) was found to be 4.9. The maximum Tropical Livestock Unit (TLU) was 13.96 while the minimum was 1. Physical asset is an essential part of wealth indicator of the household either by the definition of the community or international standard value and expected household who have more physical asset might have the probability of adopting agricultural technologies.

Table 4.7. Descriptive statistics of income and asset indicator variables

Variables	Obs. (#)	Mean	Std. Dev.	Min.	Max.
Household asset (ETB)	214	66235.09	739	10000	1355800
Farm income (ETB)	214	25533.64	55.21	8,000	96000
non-farm income (ETB)	214	1901.81	23.65	0	15000
Total land holding (ha)	214	1.81	0.79	0 .25	4
Tropical Livestock Unit (TLU)	214	4.94	2.63	1	13.96

Source: Computed from 2021 Survey in Gondar Zuria district

As shown in Table 4.7, the average value of physical household assets was 66235.09 ETB. The other important factor to adopt the new agricultural technologies was income either farm income or non-farm income. The average farm income collected annually from all farm activity was 25533.64 ETB. From the sampled respondents, the average monthly non-farm income was 1916 ETB. On average, the sampled respondent households owned 1.81 hectares of total land.

4.2. Relationship among improved management practices and household characteristics

4.2.1. Adoption of inorganic fertilizer and household characteristics

An independent sample t-test and chi-square statistics were conducted to explore a group of variables as shown in Table 4.8. This part focused on the comparison between adopters and non-adopters of inorganic fertilizer applying to sorghum. As the result showed in Table 4.8, there was no significant difference in the age of adopters (45.57 years) and non-adopters (44.78 years).

Table 4.8. Independent variables by the adoption of inorganic fertilizer

Variable	Inorganic fertilizer//Urea and NPS		
	Adopters (n_1=39)	Non-Adopters (n_2=175)	t-test/chi-square (Std.err)
Age (year)	46.57	44.78	-0.92 (1.93)
Total family size (#)	7	5.33	-5.77 *(0.28)
Farming experience (year)	23	23.18	-0.25 (0.72)
Farm income (ETB)	44302	21218	-8.75*** (1196)
Household asset (ETB)	145840	47935	-4.65***(8592)
Landholding (ha)	1.81	1.79	-0.14 (.052)
Livestock holding (TLU)	6.72	4.86	-3.71*** (0.20)
Training (#/year)	0.87	0.17	-6.55 (0.04)
Field day(#/year)	0.22	0.19	-0.37* (0.03)
Cooperative membership (yes)	70	47.13	6.81**
Education status HHs(% of literate)	62.50	17.82	33.61***
Sex (% of male)–respondent	67.50	72.99	0.48
Non-farm income (%)	55	29.89	9.06 **
Access to credit (%)	80.00	28.74	36.16***
Labor access (%)	70.00	68.97	0.016

***, **, and * indicate the level of significance at 1, 5, and 10 percent, respectively
Source: Computed from 2021 Survey in Gondar Zuria district

The Other variable was the total family size of the household head and there was a significant difference between the total family size of adopters (7) and non-adopters (5.33). There is no significant difference between adopters (23 years) and non-adopters (23.18 years) of farming experience of applying inorganic fertilizer (NPS and Urea). The farm income of adopters (44302.00 ETB) was significantly higher than the farm income of non-adopters (21218.00 ETB). This indicates those farmers who have more farm income can purchase fertilizer and can apply for sorghum production. The livestock holding of adopters (6.72 TLU) is significantly higher than livestock holdings of non-adopters (4.86 TLU). The household asset of adopters (145840 ETB) was highly significant than the household asset of non-adopters (47955 ETB). As shown in the t-test, there was no significant difference between adopters (0.87) and non-adopters (0.17) in training. There was a significant difference between adopters (0.22) and non-adopters (0.19) household participation in field day. The chi-square statistics showed in Table 8, in educational status, inorganic fertilizer adopters (62.5 %) were educated than non-adopters (17.82 %). There was a significant difference between adopters (70 %) and non-adopters (47.13 %) to be a member of membership to multi-purpose cooperative. There is no significant difference between adopters (67.5 %) and non-adopters (72.99 %) of inorganic fertilizer by sex of the respondent. Regarding the involvement of households in non-farm income, there was also a significant difference between sampled household adopters (55 %) and sampled household non-adopters (29.89 %) of inorganic fertilizer. The other variable was access to credit and there was a highly significant difference between adopters (80 %) and non-adopters (28.74 %) of inorganic fertilizer. Purchasing fertilizer is not easy for the rural household since the much expenditure of inputs at the time of planting. Therefore, farmers who have access to credit can easily purchase fertilizer. There was no significant difference between adopters (70 %) and non-adopters (68.97 %) of inorganic fertilizer by labor access.

4.2.2. Adoption of sorghum row planting practice and household characteristics

As indicated by Table 4.9, t-test and chi-square tests were conducted. This part focused on the comparison between adopters and non-adopters of sorghum row planting. As the result showed, there was no significant difference in the age of adopters (43.31 years) and non-adopters (45.58

years). The other variable was the total family size of the household head and there was a significant difference between the total family size of adopters (6.93) and non-adopters (5.31) in row planting. There was significant difference between adopters (21.29 years) and non-adopters (23.73 years) in farming experience. The farm income of adopters (42722 ETB) was significantly higher than the farm income of non-adopters (21084 ETB). This indicates those farmers who have more farm income can purchase labor and can apply row planting for sorghum production.

Table 4.9. Independent variables by the adoption of sorghum row planting practice

Variable	Sorghum row planting		
	Adopters (n_1=43)	Non-Adopters (n_2= 171)	t-tes/chi-square (Std.err)
Age (year)	43.31	45.58	1.21 (0.75)
Total family size (#)	6.93	5.31	-5.82*** (0.12)
Farming experience (year)	21.29	23.73	1.38 (0.71)
Farm income (ETB)	42722	21084	-8.42*** (1196)
Household asset (ETB)	114771	53672	-2.92*** (8592)
Land holding (ha)	1.77	1.80	0.25 (0.05)
Livestock holding (TLU)	6.33	4.92	-2.88** (0.20)
Training (#/year)	0.75	0.19	-5.25*** (0.04)
Field day(#/year)	0.20	0.20	-0.06 (0.030)
Cooperative membership (%)	77.27	44.71	14.84***
Education status HHs (% of literate)	56.82	18.24	26.93***
Sex (% of male) –respondent	68.18	72.94	0.39
Non-farm income (%)	52.27	30.00	7.66**
Access to credit (%)	70.00	47.13	24.20**
Labor access (%)	72.73	68.24	0.33

***, ** and * indicate the level of significance at 1, 5, and 10 percent, respectively

Source: Computed from 2021 Survey in Gondar Zuria district

The other variable was access to credit and there was a significant difference between adopters (70 %) and non-adopters (47.13 %) of inorganic fertilizer. There was no significant difference between adopters (72.73 %) and non-adopters (68.24 %) of row planting for sorghum by labor access. The livestock holding of adopters (6.33 TLU) is significantly higher than livestock holdings of non-adopters (4.92 TLU). The household asset of adopters (114771 ETB) was highly significant than the household asset of non-adopters (53672 ETB). As the t-test indicates in

Table 9, there was significant difference between adopters (0.75) and non-adopters (0.19) in training. There was no significant difference between adopters (0.20) and non-adopters (0.20) household-headed participation in field day. There was a significant difference between adopters (77 %) and non-adopters (44.71 %) to be a member of membership to multi-purpose cooperative. As the chi-square statistics show in Table 4.9, In educational status, there was a significant difference between adopters (56.82 %) and non-adopters (18.24 %). There is no significant difference between adopters (68.18 %) and non-adopters (72.94 %) of row planting for sorghum by sex of the respondent. Regarding non-farm income, there was also a highly significant difference between sampled household adopters (52.27%) and sampled household non-adopters (30 %) of sorghum row planting.

4.2.3. Adoption of sorghum thinning practice and household characteristics

In Table 4.10: the t-test and chi-square test explained the comparison between adopters and non-adopters of sorghum thinning practice in the study area. As the result showed, there was no significant difference in the age of adopters (45.05 years) and non-adopters (45.13 years). The other variable was the total family size of the household head and there was a significant difference between the total family size of adopters (6.88) and non-adopters (5.24). The farm income of adopters (38290 ETB) was significantly higher than the farm income of non-adopters (21334 ETB). The livestock holding of adopters (5.99 TLU) is significantly higher than livestock holdings of non-adopters (4.95 TLU). The household asset of adopters (101331 ETB) was highly significant than the household asset of non-adopters (54681 ETB). As the t-test indicates in Table 4.10, there was significant difference between adopters (0.67) and non-adopters (0.18) household regarding training access. There was no significant difference between adopters (0.22) and non-adopters (0.19) household-headed participation in field day. As the chi-square statistics show in Table 4.10: In educational status, there was a significant difference between adopters (45.28 %) and non-adopters (19.88 %). There is no significant difference between male respondent adopters (64.15%) and male respondent's non-adopters (74.53 %) of sorghum thinning practice. Regarding non-farm income, there was significant difference between sampled household adopters (45.28 %) and sampled household non-adopters (31.06 %).

Table 4.10. Independent variables by the adoption of sorghum thinning practice

Variable	sorghum thinning practice		
	Adopters (n_1= 52)	Non-Adopters (n_2= 162)	t-tes/chi-square (Std.err)
Age (year)	45.05	45.13	0.04 (0.75)
Total family size (#)	6.88	5.24	-6.43***(0.12)
Farming experience (year)	22.62	23.43	0.49 (0 .71)
Farm income (ETB)	38290	21334	-6.72*** (1196)
Household asset (ETB)	101331	54681	-2.36* (8592)
Land holding (ha)	1.80	1.80	0.00 (0.05)
Livestock holding (TLU)	5.99	4.95	-2.24* (0.20)
Training (#/year)	0.67	0.18	-4.94*** (0.04)
Field day(#/year)	0.22	0.19	-0.47 (0.03)
Cooperative membership (yes)	73.58	44.10	13.87**
Education status HHs (% of literate)	45.28	19.88	13.32***
Sex (% of male) –respondent	64.15	74.53	2.13
Non-farm income (%)	45.28	31.06	3.56*
Access to credit (%)	64.15	29.81	19.89***
Labor access	67.92	69.57	0.05

***, **, and * indicate the level of significance at 1, 5, and 10 percent, respectively

Source: Computed from 2021 Survey in Gondar Zuria district

The other variable was access to credit and there was a highly significant difference between adopters (64.15 %) and non-adopters (29.81 %) of sorghum thinning practice. There was no significant difference between adopters (16.36 %) and non-adopters (52.80 %) of sorghum thinning practice by labor access. There was a significant difference between adopters (73.58 %) and non-adopters (44.10 %) to be a member of membership to multi-purpose cooperative.

4.2.4. Adoption of sorghum ridge practice and household characteristics

As indicated by Table 4.11, the adopters and non-adopters of sorghum ridge practice were compared by t-test and chi-square test. As the result showed, there was no significant difference in the age of adopters (44.61 years) and non-adopters (45.22 years). The other variable was the total family size of the household head and there was a significant difference between the total family size of adopters (7.05) and non-adopters (5.33). There was no significant difference between adopters (22.17 years) and non-adopters (23.46 years) in farming experience. The farm

income of adopters (41907 ETB) was significantly higher than the farm income of non-adopters (21884 ETB). This indicates those farmers who have more farm income can recruit labor and can apply ridge for sorghum production. There was no significant difference between livestock holdings adopters (6.45 TLU) and livestock holdings of non-adopters (4.93 TLU). The household asset of adopters (124757 ETB) was highly significant than the household asset of non-adopters (53192 ETB). As the t-test indicates in Table 4.11, there was no significant difference between adopters (0.79) and non-adopters (0.20) household by training access. There was also no significant difference between adopters (0.20) and non-adopters (0.20) household-headed participation in field day. As the chi-square statistics show about education status in Table 11, in educational status, there was a significant difference between adopters (51.28 %) and non-adopters (20.57 %).

Table 4.11. Independent variables by the adoption of sorghum ridge practice

Variable	sorghum ridge practice		
	Adopters (n1=38)	Non-Adopters (n2=176)	t-tes/chi-square (Std.err)
Age (year)	44.61	45.22	0.31 (0.75)
Total family size (#)	7.05	5.33	-5.91***(0.12)
Farming experience (year)	22.17	23.46	0.69 (0.71)
Farm income (ETB)	41907	21884	-7.18*** (1196)
Household asset (ETB)	124757	53192	-3.28** (8592)
Landholding (ha)	1.72	1.82	0.72 (0.05)
Livestock holding (TLU)	6.45	4.93	-2.97 (0.20)
Training (#/year)	0.79	0.2	-5.38 (0.04)
Field day(#/year)	0.20	0.2	-0.06 (0.03)
Cooperative membership (yes)	71.79	46.86	7.93**
Education status HHs (% of literate)	51.28	20.57	15.56***
Sex (% of male) –respondent	69.23	72.57	0.17
Non-farm income (%)	43.59	32.57	1.71
Access to credit (%)	66.67	32.00	16.21**
Labor access	71.79	68.57	0.15

***, **, and * indicate the level of significance at 1, 5, and 10 percent, respectively

Source: Computed from 2021 Survey in Gondar Zuria district

There is no significant difference between male respondent adopters (69.23 %) and male respondents non-adopters (72.57 %) in sorghum ridge practice. There was no significant

difference between adopters (43.59 %) and non-adopters (32.57 %) households involved in non-farm income. The other variable was access to credit and there was a highly significant difference between adopters (10.75%) and non-adopters (7.01%) of sorghum ridge practice. There was a significant difference between adopters (66.67 %) and non-adopters (32.00 %) sorghum ridge practice by labor access in the study area. There was a significant difference between adopters (71.79 %) and non-adopters (46.86 %) to be a member of membership to multi-purpose cooperative.

4.3. Adoption status of improved management practices of sorghum

4.3.1. Adoption categories of improved management practices of sorghum

Adopter categories classified producers into different levels depending on their practice to try out new technology. Characterizing the adoption level might help to push the newly introduced technology to society. The level of acceptance of an innovation, which consists of five stages namely knowledge, persuasion, decision, implementation, and confirmation (Havens and Rogers, 1961). The technology adoption by the producer is different from place to place, and farmer to farmer, and it is affected by different things. In most adoption studies, the level of technology adoption is categorized as non-adopter, low-adopter, medium-adopter, and high adopter using the adoption index method. For instance, Almaz Giziew (2008), Zebib Kassahune (2014) and Mesfin Fenta (2017), Negussie Siyum (2019) found that the adoption categories, non-adopter, low-adopter, medium-adopter, and high adopter.

As indicated in Table 4.12, there are four levels of adoption of improved management practices in the study district (Gondar Zuria district). This level of adoption was determined by the proportion of land allocated for sorghum production at the time of the study. The four-level of adoption were; non-adopter, low adopter, medium adopter, and high adopter. Non- adopters were 67.29 % of the 214 respondents and they covered zero mean areas of land by improved management practices. From the respondent, 144 households did not use any of the improved management practices at the time of the study. As indicated by Table 4.12, low adopters of the household were 11 % and covered a mean of 0.216 their sorghum lands at the time of study season. From the total 214 household respondents, only 25 households were low adopters of

improved management practices of sorghum in the study area at the time of the survey. The low adopter households seldom applied all improved management practices at the time of the study season. The other level of adoption was the medium adopter category and from the total respondents, only 8.41 % of household head respondents were covered 0.503 a mean of land at the time of the survey. It is possible to say, medium adopters almost covered half of their land by the improved management practices at the study time. The other adopter category level is higher adopter, which is preferable by extension agents. High adopters were 12.62 % from the total respondent households and they covered 0.879 a mean of land by improved management practices of sorghum at the time of the study. Studies by Ermias Tesfaye (2013), Miah *et al*. (2016), Mesfin Fenta, (2017), Negussie Siyum, (2019) identified the adoption category, which was non-adopter, low adopter, medium adopter, and high adopter.

Table 4.12. Distribution of level of adoption improved management practices of sorghum

Adoption category	Obs.(n)	Mean AI	Adoption category Interval	Freq. (n)	%	SD	F
Non-adopter	214	0	0	144	67.29	0	
Low adopter	214	0.216	0.01-0.33	25	11.68	0.062	
Medium adopt.	214	0.503	0.34-0.66	18	8.41	0.069	
High adopter	214	0.879	0.67-1	27	12.62	0.122	
Total	214	0.178	0-1	214	100	0.309	2451.45***

Computed from own survey data, 2021

Improved management practices adoption by each practice

As indicated by Table 4.13, below, there was a significant difference among non-adopters, low adopters, medium adopters, and high adopters in all improved management practices of sorghum at Gondar Zuria districts. Of the total respondents, 168 were not applied row planting. Nevertheless, those farmers who do not adopt row planting do not mean that they don't apply other improved management practices of sorghum in the study area. On the other hand, non-adopter farmers have covered 0 % by row planting from the total sorghum land coverage at the time of the study season. From the total respondent, only two households covered 0.235 a mean of land by row planting out of sorghum total coverage in the production year. In the category of

medium adopter of row planting, 13 (6.07 %) have covered 0.498 a mean of land from the household total sorghum area allocation at the time of study season. The most preferable category by the extension agent is high adopters, from the 214 respondent households 31 respondents were high adopters of row planting of sorghum and they covered 0.969 mean of land covered by row planting. The low adoption rate of row planting of sorghum might be the decision of farmers to save labor budget. This result is consistent with Muhammed Shako *et al.* (2020) who reported low adoption of row planting due to lack of labor.

As indicated in Table 4.13, non-adopters of inorganic fertilizer were 78.5 % and they covered 0 % of land from the total allocated land for sorghum. Low adopters, medium adopters, and high adopters of inorganic fertilizer covered 0.22, 0.495, and 0.977 mean of land by organic fertilizer respectively.

Table 4.13. The adoption level of improved management practices

Management practices	Level of Adoption	Freq.	%	Mean Ado.Ind	SD	F
Row planting	Non-adopter	168	0	0	0	6522.24***
	Low-adopter	2	4.34	0.235	0.021	
	Med. Adopter	13	28.26	0.498	0.080	
	High adopter	31	67.39	0.969	0.082	
	Total	214	100	0.172	0.351	
Inorganic fertilizer	Non-adopter	169	0	0	0	8225.49***
	Low-adopter	2	4.44	0.22	0	
	Med. Adopter	14	31.11	0.495	0.078	
	High adopter	29	64.45	0.977	0.069	
	Total	214	100	0.166	0.345	
Ridge practice	Non-adopter	173	0	0	0	7993.50***
	Low-adopter	2	4.88	0.235	0.021	
	Med. Adopter	11	26.83	0.506	0.091	
	High adopter	28	68.29	0.976	0.069	
	Total	214	100	0.156	0.340	
Thinning practice	Non-adopter	159	0	0	0	13515.34***
	Low-adopter	1	1.82	0.22	0	
	Med. Adopter	14	25.45	0.506	0.091	
	High adopter	40	72.73	0.993	0.039	
	Total	214	100.00	0.219	0.393	

Source: computed own survey data, 2021

Low adoption of inorganic fertilizer for sorghum production might be the decision of farmers due to low collection farm income, or unable to purchase fertilizer this result is almost in line with (Negera Eba and Getachew Bashargo, 2014) who reported low adoption of chemical fertilizer low farm income. The other types of improved management practice were ridge practice. The ridge practice is the important parameter to increase plant growth by avoiding excess water from the farm (Ertiban Wondifraw *et al*., 2017). As indicated in Table 4.13, from the total respondents, 173 were covered 0 % by ridge practice out of the total allocated for sorghum production at the time of the survey.

Low adopters, medium adopters, and high adopters of ridge practices of sorghum covered 0.235, 0.506, and 0.976 mean of land by ridge practice out of the total land allocated for sorghum in the study district at the time of the survey. The total adoption rate of ridge practices of sorghum in the study area was 21.5 %, and still, this adoption rate is low (Mesfin Fenta, 2017) repotted that chickpea technology adopter category is below 35% is not sufficient.

The thinning practice of sorghum is the major factor, which helps to increase productivity through increase plant growth (Ertiban Wondifraw *et al*., 2017). As indicated in Table 4.13 below, the Non-adopter category of thinning practices covered zero mean of land from the total coverage of sorghum at the time of the survey. Low adopters, medium adopters, and high adopters have covered 0.22, 0.506, and 0.993 mean of land from the total land covered respectively. In the study area, the adoption rate of thinning practices of sorghum is still low and this result is near with (Mesfin Fenta, 2017).

Adoption status of management practices of sorghum

The adoption status of improved management practices of sorghum in the study area was done by using the total area coverage of improved management practices from the total area coverage of sorghum. As figure 4.5 describes below, the adoption status of improved management practices of sorghum in the study area. The figure showed the thinning practice for sorghum production was 30.72 % and which was higher than other improved management practices. The

other improved management practices of sorghum were row planting, inorganic fertilizer, and ridge practices and the status of adoption was 24.16 %, 23.32, ridge practice, respectively.

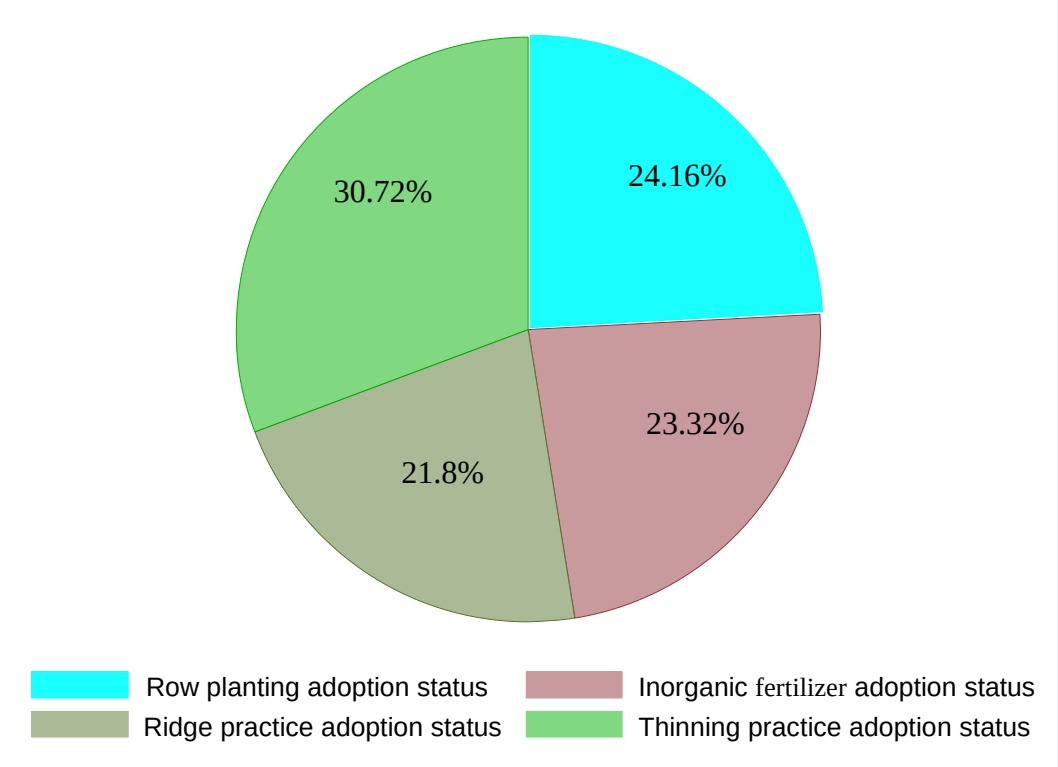

Figure 4.5. Adoption status of improved management Practices

4.3.2. Area allocated for improved and local management practices of sorghum

Table 4.14 describes the average area coverage by sorghum production. The average area allocated under the improved management practices of sorghum was 0.09 ha of land with a standard deviation of 0.16,

Table 4.14. The area allocated for sorghum production

Adoption category	Obs.(n)	Mean land	SD	Min.	Max.
Improved management	214	0.09	0.16	0	0.75
Local management	214	0.41	0.25	0	1

Source: computed own survey data, 2021

while the average area coverage of local management practices was 0.41 ha of land in the study area at the time of the survey.

Improved management practices of sorghum information source

During the time of the survey, sorghum producer farmers were asked about the improved management practices of sorghum information sources for the first time. As shown from their answers, neighbors and relative farmers, the office of agriculture, and research centers were the major source of information about the improved management practices in the study area. As indicated by figure 4.6, below most respondent households got information from the office of agriculture, and next to this neighbor and relatives and research center would give information about the improved management practices of sorghum for sorghum producer farmers. The same result by Mesfin Fenta (2017),and Negussie Siyum (2019).

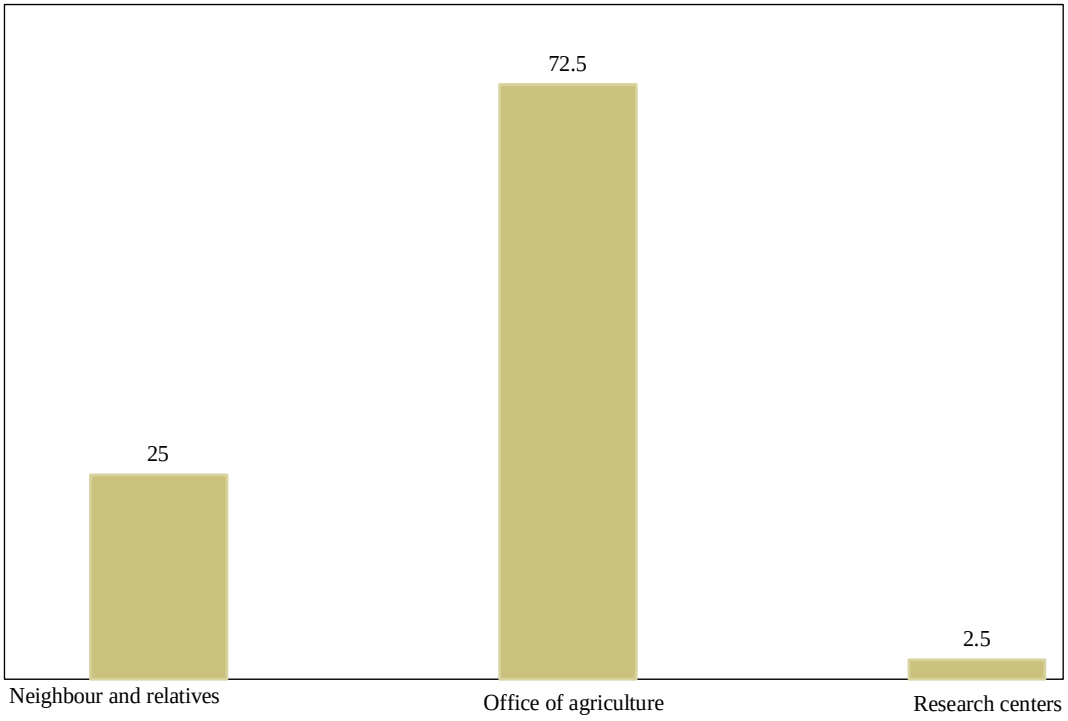

Figure 4.6. Improved management practices of sorghum information source

4.4. Econometric Model Results

Probability of success and failure

The number of joint probabilities corresponding to the different combinations of improved management practices of sorghum adoption was determined by 2M (Cappellari and Jenkins, 2003).

As indicated in Table 4.15, the output of the multivariate probit model has shown the predicted inorganic fertilizer on sorghum, sorghum row planting practice, sorghum thinning practice, and sorghum ridge practice were 18.3%, 22.7%, 28.1%, and 21.4%, respectively. On the other hand, as looked in Table 4.16 sorghum producer farmers in the study district would be a success in adopting all improved management practices of sorghum and failed to adopt all improved management practices of sorghum at a time were probably 11.5 % and 64.3 %, respectively.

Table 4.15. Predicting the probability of sorghum improved management practices

Improved management practices	Obs.	Mean	Std. Dev	Min.	Max.
Predicted probability of inorganic fertilizer	214	0.183	0.26	0.00	0.99
Predicted probability of row planting	214	0.227	0.26	0.00	0.99
Predicted probability of thinning practice	214	0.281	0.25	0.00	0.99
Predicted probability of ridge practice	214	0.214	0.22	0.00	0.97

Source: computed from own survey data 2021

Table 4.16. Probability of success and failure of sorghum improved management practices

Improved management practices	Obs.	Mean	Std. Dev	Min.	Max.
Success probability	214	0.115	0.21	0.00	0.99
Failure probability	214	0.643	0.29	0.00	0.99

Source: computed from own survey data 2021

4.4.1. Factor affecting adoptions of sorghum improved management practices

The multivariate probit model was employed to analyze the factors affecting the adoption of improved management practices of sorghum. The dependent variables, therefore, were the improved management practices of sorghum adopted by farm households. The improved management practices were; inorganic fertilizer, sorghum row planting, sorghum thinning practice, and sorghum ridge practice. The independent variables were the age of the respondent household head, sex of the respondent household head, education level of the household head, the farming experience of the respondent household head, total family size, membership of the cooperative, farm income, non-farm income involvement, access to credit, training participation, field day participation, household asset, labor access, total land holding, and total livestock holding (TLU). As the results of the multivariate probit model (MVP) showed in Table 4.17, the regressions were done at the plot based.

The Wald chi-square statistic was used to test the overall significance of variables. The likelihood test was used to test the dependency of improved management practices of sorghum on the selected independent variables in the model. The likelihood ratio test of the null hypothesis of the interdependence of the improved management practices of sorghum ($\rho 21 = \rho 31 = \rho 41 = \rho 32 = \rho 42 = \rho 43 = 0$) was significant at a 1 % level. This implies that the null hypothesis all the ρ (rho) values were simultaneously equal to zero rejected while the alternative hypothesis was accepted, and it showed the goodness of fit of the model, and the decision to adopt improved management practices of sorghum was interdependent. The model result indicated that explanatory variables were simultaneously related to the adoption of inorganic fertilizer, row planting, thinning practice, and ridge practice at a 1% level of significance for the production of sorghum. Therefore, the model has good explanatory power.

Moreover, as indicated in the appendix, problems of multicollinearity were checked by using VIF (variance inflation factor) were found to be a mean of 2.23, indicating there was no multi-collinearity problem. In addition, as shown in the appendix heteroscedasticity and omitted variables were checked by the Breusch-pagan test and Ramsey RESET test, respectively. The Breusch-pagan/ Cook-Weisberg test for heteroscedasticity showed a chi-square value of 34.7,

31.12, 12.36, and 38.07 for inorganic fertilizer, row planting, thinning practice, and ridge practice respectively. Therefore, this showed that there was a heteroscedasticity problem in the model. To found the correct variance estimator, a robust technique was used in the model. The other was the Ramsey RESET test, indicating there are no omitted variables in the model. As the multivariate probit model, the result indicated in Table 4.17, factors affecting the adoption of improved management practices of sorghum were estimated. The model was estimated 15 variables. From this, 9 variables were continuous while the rest were categorical variables.

4.4.1.1. Inorganic fertilizer

As the result of the multivariate probit model indicated in Table 4.17, three variables were significantly affecting the decision of farmers to apply inorganic fertilizer /NPS and Urea/ on sorghum crops. Total family size, sex of the respondent, and farm income of the household were the factors that affecting inorganic fertilizer for sorghum. More Labor availability in the household might influence the farmers' decision regarding the adoption of improved management practices of sorghum. Because by its nature improved management practices demand high labor. Therefore, households that have large family sizes can adopt inorganic fertilizer for sorghum production.

As the multivariate probit model indicated in Table 4.17, total family size has a positive and significantly influences adoption of inorganic fertilizer at a 10 % level of adoption. Farmers who have a large family can apply fertilizer easily on appropriate planting dates and properly based on the recommended amount. Usually, it is true that, large family size can produce better income in different ways; and can purchase commercial fertilizer /Urea and NPS. The multivariate probit model in Table 4.17 shows that the positive association between family size and inorganic fertilizer means the likelihood of adopting inorganic fertilizer on sorghum increases as the family size increases. The same result is obtained by Teame Hailemariam (2011), Chilot Yirga and Hassan1 (2013), Negera Eba and Getachew Bashargo (2014),Yirssaw Demeke (2019), and Haileslasie Gereziher and Gidey Kidu (2021).

Farm income has positively and significantly influenced the adoption of inorganic fertilizer at a 5 % level of adoption. In Ethiopia, inorganic fertilizer is one of the imported inputs of an agricultural commodity. Therefore, the price of inorganic fertilizer is high relative to other agricultural inputs. This implies those farmers who have a better farm income can afford fertilizer price and purchase it for sorghum production, and it helps to apply based on the recommended rate of fertilizer. As indicated in Table 4.17, the multivariate probit model shows that the positive association between farm income and inorganic fertilizer means the likelihood of adopting inorganic fertilizer on sorghum increases as the farm income increases. This result is similar to Negera Eba and Getachew Bashargo (2014), Mesfin Fenta (2017), Yirssaw Demeke (2019).

Respondent sex has negatively and significantly affected the adoption of inorganic fertilizer at a 10% level. As indicated in Table 4.17, the negative sign of the coefficient indicates that female-headed households are more adopters of inorganic fertilizer for sorghum production than male-headed households in the study district area. This might be due to women farmers may have small land sizes, and they might prefer high sorghum production within a small area of land. In Ethiopia, mostly women household farmers have low expenditure than male-headed households because male farmers have high expenditures, especially for beers. Women farmers avoiding inessential costs and they have to apply fertilizer for sorghum production. This result supported by Hirut Haile (2008) suggested that micro-loan finance is more and prioritize for women head farmers. Studies by Deressa *et al*., (2008), Mesfin Fenta, (2017), and Menasbo Gebru (2021) found to be sex affects agriculture technology adoption. This study is the same like Mesfin Fenta, (2017), and Menasbo Gebru (2021).

4.4.1.2. Sorghum row planting

As the result of the multivariate probit model indicated in Table 4.17, five variables significantly affected the decision of farmers to practice row planting. These were: total family size, sex of the respondent, membership to cooperatives, farm income of the household, and field day participation.

As indicated by Table 4.17, total family size has a positive and significant influence on the adoption of row planting of sorghum at a 1 % level. The source of the labor force is either market or family. Large family size has a probability of much active labor force. On the other hand, labor is the major important factor to apply row planting of sorghum. As the multivariate probit model indicates in Table 4.17, the positive association between sorghum row planting and family size. This means there is the probability of increasing the adoption of sorghum row planting as the family size increases. Mostly row planting demands labor Therefore, households having large family sizes have a higher probability of adopting sorghum row planting practices than low family size members. The same result was found by Mahdi Egge *et al*. (2010), Negese Tamirat *et al*. (2017), Almaz Giziew and Begashaw Mebrate (2019), and Menasbo Gebru, 2020).

The sex of the respondent has a negative and significant influence on the adoption of row planting at a 10 % level of significance. As an extension package, row planting of sorghum is one of the practices, which helps to increase the productivity of sorghum in the study area. Different extension methods have been delivered by the extension agents, such as group discussion, training, leaflets, face to face and mobile service to transfer sorghum row planting package. In Table 4.17, The multivariate probit model indicates that the adoption of row planting of sorghum practice increases as being a female-headed household in the study area. Therefore, the female-headed household has a better probability of adopting sorghum row planting than the male-headed households. This could be women have easily internalized these extension services because mostly they have low landholding, and again they have the interest to increase productivity within a small land This finding is in line with Gedefaw Abebe and Sisay Debebe (2019), Girma Gezimu, (2019), and Menasbo Gebru (2021).

Membership to multi-purpose cooperatives has positively and significantly influenced the adoption of sorghum row planting at a 5% level. Primary multi-purpose cooperatives have organized and deliver market information, training, field day, on-farm demonstration, and different discussion. Therefore, farmers who are a member of the multi-purpose cooperative have more information and awareness to sorghum row planting practice. The multivariate probit model result indicates that the positive and significant association between sorghum row planting practice and membership to cooperatives means the likelihood of adopting row planting of

sorghum increases as being a member of primary multi-purpose cooperatives in the study district. This finding is the same as Berihun Kassa *et al*. (2014), and Bekele Wegi (2020). The other research conducted by Aman Tufa and Tewodros Tefera, (2016) Bekele Wegi (2020) found that membership to cooperatives has a positive and significant effect on technology adoption of agricultural technologies.

Farm income of the household has positively and significantly influence on the adoption of sorghum row planting at a 1% significance level. A household earning a high farm income is okay to take risk of the new management practice. The row-planting method of sorghum indeed demands high labor and time than the method of broadcasting of sorghum. Therefore, farmers who are collecting more farm income have a chance of recruiting labor from the market and can apply the row-planting practice. So it implies that farmers who are collecting more farm income annually have the probability of adopting sorghum row planting practice than farmers who are collecting low farm income annually. As the multivariate probit model indicates a positive association between sorghum row planting and farm income of the households means the likelihood of adopting row planting of sorghum increases as the farm income of the households. The result is the same as Negera Eba and Getachew Bashargo (2014), and Yirssaw Demeke (2019).

Field day participation has positively and significantly influenced the adoption of sorghum row planting at a 10 % level significance level. The potential reason might be farmers have exposure to information about the row planting practice. Field days might be organized by different extension organizations at different times with different objectives. In the study district sorghum, improved management practice field day has been organized by the collaboration of stakeholders, and farmers who have participated in the field day have more information about the row planting of sorghum practice. As the result of the multivariate probit model indicates, the positive association between row planting of sorghum and field day participation means the likelihood of adopting row planting of sorghum increases as increases of the field day participation in the study area. This result is the same as Hadush Hagos *et al*. (2018), and Mesfin Fenta (2017).

4.4.1.3. Thinning practice

As the result of the multivariate probit model indicated in Table 4.17, five variables significantly affected the decision of farmers to practice thinning on sorghum. Thus were; total family size, sex of the respondent, membership to cooperatives, farm income of the household, and field day participation.

As shown by Table 4.17, total family size has a positive and significant effect on sorghum tinning practice adoption at a 1 % level significance. The Source of the labor force is either family or the market and thinning practice demands high labor. This means a large family size can do thinning the high population of sorghum easily. Therefore, farmers who have large family size members have a better probability of sorghum thinning practice based on the recommended spacing of agronomic practice. The result of the multivariate probit model indicates the positive association between sorghum thinning practice adoption and family size means the likelihood of adopting thinning practices of sorghum increases as the increase of family members. This result is the same as Mahdi Egge *et al*. (2010), Negese Tamirat *et al*. (2017), Almaz Giziew and Begashaw Mebrate (2019), and Menasbo Gebru (2020).

As with the row planting, the sex of the respondent has a negative and significantly affects the adoption of sorghum thinning practice at a 5 % level. Being a male-headed household was not adopters of sorghum thinning practice in the study area. A female-headed household has a better probability of adopting sorghum row planting than the male-headed households. This is because the task is easy for female-headed households and can easily put a decision to adopt the thinning practice than the male-headed household. As the result of the multivariate probit model indicates in Table 4.17, having a positive correlation between the thinning practice of sorghum and family size implies there might be a probability of adopting sorghum thinning practice increases as the family member increases. This findings is the same like Ermias Tesfaye (2013), Gedefaw Abebe and Sisay Debebe (2019), Girma Gezimu (2019), and Menasbo Gebru, (2021).

Membership to multi-purpose cooperatives has positive and significant effects on the adoption of sorghum thinning practice at a 10 % level. As indicated by its name multi-purpose cooperative working on different activities, it might be advisory role, on-farm demonstration, and delivered

extension service. A multi-purpose cooperative gives the service primarily for the members. Therefore, members of multi-purpose cooperatives have good exposure to information and awareness about thinning practice of sorghum. As the multivariate probit model is shown, the positive association between thinning practice of sorghum and primary multipurpose cooperatives implies increasing adoption of thinning practices of sorghum as being a member of the primary multi-purpose cooperative. Therefore, the members of multi-purpose cooperative have a probability of being adopters of sorghum thinning practices than non-members in the study area. This finding in line with Berihun Kassa (2014), Bekele Wegi (2020), and Susie Teshome and Bosena Tegegne (2020).

Farm income of the household has positive and significant effects on adoption sorghum thinning practice at a 5 % level significance. Usually, sorghum-thinning demands huge labor either family labor or market labor. Sorghum producer household who have not enough active family labor force has a choice of recruiting labor. Now a day's recruiting labor demands a high budget therefore the households who have a better farm income annually can be recruiting labor to thinning practice. As indicated by the multivariate probit model in Table 4.17, the positive association between thinning practices of sorghum and farm income of the household means the likelihood of adopting sorghum-thinning practices as the household farm income increases. Therefore, farmers who have collecting a better farm income have a probability of adopting sorghum row planting than low farm income households. The findings of Negera Eba and Getachew Bashargo (2014), and Yirssaw Demeke (2019)

Field day participation has a positive and significant effect on sorghum-thinning practices at a 10 % level significance. Field day is the method of transferring the new technologies for agricultural extensions and the market for farmers to purchase the new technology available either on the field or the shelf. Therefore, the potential reasons might be, the farmers involved in the field day have exposure to the merits of the thinning practices and have a probability of avoiding their confusion. Therefore, farmers who were invited on the field day can easily internalize the information and can adopt the thinning practices of sorghum. As the multivariate probit model shown in Table 4.17, the positive association between thinning practices of sorghum and field day participation implies that the probability of adopting thinning practices of sorghum increases

with more participation on field day. The same result was found by (Hadush Hagos *et al*. (2018), Bekele Wegi (2020).

4.4.1.4. Ridge practice

Total family size has a positive and significant effect on the adoption of sorghum ridge practice at a 1 % level significance. Ridge practice demands a high labor force because the practice is not easy as the other practices. It is widely accepted that the source of labor is either a family member or the market. Therefore, farmers who have large family sizes can apply the ridge practice on sorghum. This implies that farmers who have large family size being the probability of adopter of sorghum ridge practice than farmers' have low family size. As the multivariate probit model indicates in Table 4.17, the positive correlation between ridge practices of sorghum and family size means the likelihood adopting of ridge practices of sorghum increases as the increase of family members of the household. This result is in line with Mahdi Egge *et al*. (2010), Bekele Wegi (2020), and Menasbo Gebru (2020).

The total landholding has negatively and significantly influenced the adoption of sorghum ridge practice at a 10 % level of significance. Usually, indeed, farmers who have large landholdings do not practice ridge to produce sorghum because it demands high labor costs. It might be, in the study district, large landholding households prioritize teff and wheat to the applied ridge when most of their land is covered by those crops. On the other hand, when most of their farms were covered by sorghum and they would not apply ride for sorghum because it needs high labor. Therefore, it is true that farmers who have large landholdings can't apply ridge for sorghum production. Large landholding households lead to a decrease in the probability of ridge practice adoption relative to small landholding households. As indicated by the multivariate probit model in Table 4.17, there is a negative association between ridge practices of sorghum and landholding implies that the probability of adopting ridge practices of sorghum decreases as the large landholding. This result is the same as Teame Hailemariam (2011), Ermias Tesfaye (2013, Berihun Kassa (2014), Jafer Mume and Aman Kemal (2014), and Menasbo Gebru (2021).

Farm income has positive and significant effects on the adoption of sorghum ridge practices at a 1 % level of significance. In the study district, sorghum ridge practice indeed required a huge amount of labor. The time of ridge on sorghum is on a specific time date, therefore might not be done at this specific time. So that ridge practiced on this specific date requires a high amount of labor force. As we discussed in thinning practice, the source of the labor force is either market or family, due to this farmers who have to collect a better farm income annually can afford labor from the market and can recruiting labor for ridge practice. As indicated by the multivariate probit model in Table 4.17, the high correlation between ridge practice of sorghum and farm income implies that the likelihood of adopting the ridge practice of sorghum increases as more farm income collects annually. Therefore, farmers who have better farm income being an adopter of ridge practice. This result is the same as Negera Eba and Getachew Bashargo (2014), and Mesfin Fenta (2017).

Table 4.17. Results of multivariate probit model analysis of improved management practices of sorghum

Variables	Inorganic fertilizer		Row planting		Thinning practice		Ridge practice	
	Coef	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
Farm experience of the household head	-0.033	0.026	0.003	0.020	-0.021	0.023	0.006	0.024
Total Family Size (#)	0.185*	0.083	0.263***	0.066	0.306***	0.070	0.278***	0.063
Age of respondent in yrs.	0.030	0.028	-0.023	0.020	0.014	0.022	-0.009	0.022
Respondent Sex	-0.561*	0.281	-0.545*	0.246	-0.740**	0.246	-0.241	-0.226
Education level of the household head	0.468	0.313	0.235	0.264	-0.070	0.274	0..209	0.272
Total landholding in ha	-0.045	0.239	-0.060	0.147	-0.006	0.162	-0.301*	0.142
Access to credit	0.581	0.290	0.144	0.225	0.319	0.245	0.004	0.245
Multi-purpose cooperative membership	0.094	0.292	0.717**	0.250	0.501*	0.231	0.295	0.215
Farm income of the household in birr/yr.	0.938**	0.301	1.035***	0.222	0.664**	0.228	0.795***	0.200
Non-farm income involvement	0.208	0.292	0.236	0.236	0.084	0.236	-0.112	0.202
Training participation within a year	-0.044	0.189	-0.079	0.133	-0.101	0.124	-0.186	0.132
Field day participation within a year	0.264	0.193	0.294*	0.146	0.309*	0.140	0.228	0.190
Labor Market access	0.330	0.290	0.193	0.238	0.059	0.234	0.243	0.224
Household Asset in ETB	0.343	0.189	0.023	0.165	0.010	0.137	0.259	0.165
Livestock holding (TLU)	0.026	0.037	0.010	0.044	-0.002	0.041	0.009	0.042
Constant	-16.903***	3.458	-12.457***	2.652	-9.216***	2.584	-12.721***	2.600
$\rho_{21\ (rho21)}$	0.830***							
$\rho_{31\ (rho31)}$	0.636***							
$\rho_{41\ (rho41)}$	0.647***							
$\rho_{32\ (rho32)}$	0.866***							
$\rho_{42\ (rho42)}$	0.909***							
$\rho_{43\ (rho43)}$	0.859***							
Wald chi2(60)	588.69***							

Likelihood ratio test of independence $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{32} = \rho_{42} = \rho_{43} = 0$, ρ -value < 0.000

*, **, and *** 10, 5 and 1 % significant level respectively. Computed from own survey 2021 data

The correlation matrix of improved management practices of sorghum

As indicated in Table 4.18, the row planting of sorghum, inorganic fertilizer, thinning practice, and ridge practice have been highly correlated. The decision of framers to apply row planting on sorghum would also adopt inorganic fertilizer, thinning practice, and ridge practice. The farmers have applied row planting, inorganic fertilizer, thinning practice, and ridge practice simultaneously. The improved management practices of sorghum, inorganic fertilizer application, ridge practice, thinning practice, and row planting practice are interdependent. The decision to use one practice also enforces to use of the other improved management practices of sorghum. Therefore sorghum producer farmers who are trying to use improved management practices of sorghum at the same time since they are interdependent, and the interdependence of each improved management practice of sorghum would be easy for extension workers.

Table 4.18. Correlation matrix of improved management of sorghum

Correlation matrix variables	z-value
Row planting and inorganic fertilizer (rho_{21})	17.86***
Thinning practice and inorganic fertilizer (rho_{31})	7.32***
Ridge practice and inorganic fertilizer (rho_{41})	9.23***
Thinning practice and row planting (rho_{32})	17.00***
Ridge practice and row planting(rho_{42})	22.37***
Ridge practice thinning practice (rho_{43})	16.09***

Source: computed from own survey 2021 data

4.5. Farmer perception towards sorghum Improved management practices

Reliability tests for conjoint analysis

The reliability test (the internal consistency) of the goodness of attributes specified in the study area for the Likert scale method. As indicated the Table 4.19, Cronbach's alpha value of sorghum growers was 0.906 in the study area. Therefore, it implies that the alpha coefficient value of 0.906 is accepted since it is greater than 0.6, so internally consistent and sTable (Bernstein and Putnam, 1986). Therefore, in this research, the sum item of the instrument had 0.906 Cronbach's

Alpha value. It is true that depending on Cronbach's alpha value, this study instrument has a high level of reliability for the study area.

Table 4.19. Instrument reliability statistics high level of reliability

Cronbach's Alpha	Cronbach's Alpha Based on standardized items	Number of items
.906	.906	16

Source: **c**omputed from own survey data 2021

4.5. 1. Relative importance index of inorganic fertilizer attributes

Farmers' perception attributes and participation are very important to bring technology to the farmers. The perception of farmers about the application of inorganic fertilizer/ UREA and NPS/ on sorghum has been measured by the criteria of plant growth, biomass yield, grain yield, and maturity date. These criteria were measured by Likert scale data analysis. The Likert scale analysis method would measure the score of each respondent regarding the specific practices. The perception of farmers has greater importance for the adoption of inorganic (Yirssaw Demeke, 2019).

As shown in Table 4.20, measures farmers' perception of inorganic fertilizer application on sorghum production. The relative importance index has shown the higher relative importance index attribute was the important attribute. Based on the relative importance index, fertilizer application for plant growth (0.9345794) was the most important attribute by sorghum producer farmers.

Table 4.20. Relative importance index of fertilizer attributes on sorghum

Attributes	Relative importance index	Attribute Rank
Inorganic fertilizer used to plant growth	0.9345794	1th
Inorganic. fertilizer used to increase biomass	0.9336449	2th
Inorganic. Fertilizer used to increase grain yield	0.911215	3th
Inorganic. fertilizer used to early maturity date	0.8878505	4th

Computed; own survey 2021

The other attributes, fertilizer application to increase biomass yield (0.9336449), fertilizer application to increase grain yield (0.911215), and fertilizer application for early maturity date (0.8878505) attributes were as important as the layout respectively.

4.5. 2. Relative importance index of row planting attributes

Farmers have a low perception towards row planting of sorghum and teff relative to other crops. The perception of farmers about the row planting practice on sorghum has been measured by the criteria of reducing seed cost, yield increment, easy management, and proper fertilizer placement. These criteria were measured by Likert scale data analysis. The Likert scale analysis method would measure the score of each respondent regarding sorghum row planting practice. A positive perception of farmers regarding row planting is important to adopt row planting (Negussie Siyum, 2019; Mesfin Fenta, 2017).

As indicated by Table 4.21, measures farmers' perception of row planting on sorghum production. The relative importance index has shown the higher relative importance index attribute was the important attribute. Based on the relative importance index, row planting to reduce seed cost (0.8990654) was the most important attribute by sorghum producer farmers. The other attributes, Row planting to yield increment (0.8878505), row planting to easy management (0.8691589), and row planting to proper fertilizer placement (0.8588785) attributes were as important as the layout respectively.

Table 4.21. Relative importance index of row planting attributes on sorghum

Attributes	Relative importance index	Attribute Rank
Row planting to reduce seed cost	0.8990654	1th
Row planting to yield increment	0.8878505	2th
Row planting to easy management	0.8691589	3th
Row planting for proper fertilizer placement	0.8588785	4th

Source: computed from own survey data, 2021

4.5. 3. Relative importance index of thinning practice attributes

The perception of farmers about the thinning practice on sorghum has been measured by the criteria of yield increment, help for weed and pest management, fertilizer management. These criteria were measured by Likert scale data analysis. The Likert scale analysis method would measure the score of each respondent's response regarding sorghum thinning practice. A better perception of farmers about sorghum Intra and interspacing agronomic management is important (McGuire *et al*., 2012). As indicated by Table 4.22, measures farmers' perceptions of thinning practice on sorghum production. The relative importance index has shown the higher relative importance index attribute was the important attribute. Based on the relative importance index thinning practice to increase yield (0.8990654) was the most important attribute by sorghum producer farmers. The other attributes, thinning for weed and pest management (0.8878505), thinning important for fertilizer management (0.8691589), and thinning increase biomass yield (0.8588785) attributes were as important as the layout respectively.

Table 4.22. Relative importance index of sorghum thinning practice

Attributes	Relative importance index	Attribute Rank
Thinning for increased yield	0.8560748	1th
Thinning help for weed and pest management	0.8523364	2th
Thinning important for fertilizer management	0.8495327	3th
Thinning increases biomass yield	0.7429907	4th

Source: computed from own survey data, 2021

4.5.4. Relative importance index of ridge practice attributes

Waterlogging contributes to reducing grain and biomass yield especially in the agro ecology of the midland. Sorghum crop needs moderate soil moisture to give high grain and biomass yield so in this regard ridge practice helps to control the excess water (Ertiban Wondifraw *et al*., 2017). The perception of farmers about the ridge practice on sorghum has been measured by the criteria of waterlogging, grain yield, plant growth, and its applicability. These criteria were measured by Likert scale data analysis. The Likert scale analysis method would measure the score of each respondent regarding sorghum ridge practice. The better perception and knowledge of farmers

about ridge practice is the major important parameter to increase production (McGuire et al.,2012). As shown in Table 4.23, measures farmers' perception of thinning practice on sorghum production. The relative importance index showed the higher relative importance index attribute was the important attribute. Based on the relative importance index, ridge practice to reduce waterlogging (0.8990654) was the most important attribute by sorghum producer farmers. The other attributes, ridge to increase yield (0.8878505), ridge to plant growth (0.8691589), and ridge to easy applicability (0.8588785) attributes were as important as the layout respectively.

Table 4.23. Relative importance index of ridge practice attributes

Attributes	Relative importance index	Attribute Rank
Ridge to reduce waterlogging	0.9046729	1th
Ridge to increase yield	0.8869159	2th
Ridge to plant growth	0.8785047	3th
Ridge to easy applicability	0.6729972	4th

Source: computed from own survey data 2021

4.5. 5. Perceived relative preference of sorghum improved management practices

As indicated by Table 4.24, in the study district the measurement criteria of farmer's perception were different criteria for each improved management practice of sorghum. Inorganic fertilizer practice perception was measured by plant growth, increasing biomass yield, increasing grain yield, and early maturity date. Row planting practice perception was measured by reducing seed cost, increasing grain yield, easy management, and helps for proper fertilizer placement. Thinning practices of sorghum perception were measured by increase grain yield, helps to weed and pest management, proper fertilizer placement.

The ridge practice perception was measured by reducing waterlogging, increasing grain yield, improving plant growth, and applicability. The explanation of the perception data was five score means the highest value while the lowest score was 1, (5 = strongly agree, 4= agree, 3= neutral, 2= disagree, and 1= strongly disagree).

Table 4.24. Relative importance index of ridge practice attributes

List of preference attributes	Distribution of respondents on based on the perception of improved management practices of sorghum (Frequency)						
	Strongly Agree	Agree	Neutral	disagree	Strongly Disagree	mean	SD
Inorganic fertilizer							
↑$_{se}$ plant growth	160	44	4	6	0	4.67	0.653
↑$_{se}$ biomass	139	63	4	8	0	4.55	0.714
↑$_{se}$ grain yield	160	44	3	7	0	4.66	0.669
early maturity	131	62	10	10	1	4.45	0.825
Row planting practice							
↓$_{se}$ seed cost	135	61	8	9	1	4.49	0.797
↑$_{se}$ grain yield	132	62	8	14	0	4.43	0.846
Easy management	108	83	12	11	0	4.34	0.806
Prop. Fertilizer. plac.	103	89	7	12	3	4.29	0.884
Thinning practice							
↑$_{se}$ grain yield	99	92	8	14	1	4.28	0.853
Weed and pest mang't	100	89	8	15	2	4.26	0.896
Fertilizer mang't	91	97	14	12	0	4.24	0.81
↑$_{se}$ biomass	69	71	19	54	1	3.71	1.178
Ridge practice							
↓$_{se}$ water logging	141	55	8	9	1	4.52	0.797
↑$_{se}$ grain yield	125	70	7	11	1	4.43	0.823
↑$_{se}$ plant growth	119	73	10	11	1	4.39	0.836
easy applicability	37	84	13	80	0	3.36	1.153

Source: computed from own survey data 2021

Note: mang't = management, plac. = placement, ↓$_{se}$= decrease, ↑$_{se}$= increase

Chapter 5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The improved management practices of sorghum are inorganic fertilizer, row planting, thinning practice, and ridge practice. Each improved management practices of sorghum are interdependent. Statistically, there is a significant difference among adopters and non-adopters concerning total family size, farm income, household asset, field day, education status of the household, non-farm income, and access to credit.

Multivariate probit model result indicates that total family size, respondent household head sex, and farm income significantly affect the adoption of inorganic fertilizer for sorghum production. By its nature improved management practices of sorghum require high labor; therefore utilization of the idle family labor is necessary. In addition to this, multivariate probit model result revealed that total family size, respondent household head sex, membership to multipurpose cooperative, farm income, and field day significantly determines the adoption of row planting and thinning practices of sorghum. It also indicates that the total family size, total land holding, and farm income of the household determine the adoption of ridge practices of sorghum. The multivariate probit model result also indicates the predicted value to all improved management practices and identifies the probability of failure and success of sorghum producer farmers to adopt or not to adopt improved management practices at the same time.

The adoption level is categorized using the adoption index, found to be identified as non-adopters, low-adopters, medium adopters, and high adopters. The number of non-adopters improving management practices of sorghum was high while the category of high adopters was very low. On the other hand, the adoption statuses of improved management practices of sorghum are identified. Based on this, thinning practices are more adopted relative to the other improved management practices of sorghum.

Farmer perception about improved management practices of sorghum has been determined by different attributes in the study area. Even if, many farmers have a positive perception regarding the improved management practices of sorghum, their perception has not equal for each attribute

for each management practice. Therefore, respondents of the household head highly preferred the attribute of the growth of the plant in the management of inorganic fertilizer. On average, the household head also highly preferred the attributes of reducing seed cost for row planting management practice. The other improved management practice is thinning practice, and by this also the respondents highly preferred the attributes of increasing yield.

Therefore, sorghum is characterized by low production and productivity, traditional practice, and low input utilization. To address this challenge, decision-makers need to be made based on empirical evidence and a clear study of the implementation process to ensure food security for farmers by increasing production.

5.2. Recommendation

By considering the major findings of the study, the researcher forwarded the following recommendations.

The agricultural extension experts should increase sorghum grain yield through proper utilization of family labor, preparing frequent field visits, farmers to be part of the multi-purpose primary cooperative, and raising the income of farmers from the farm activities. Since improved management practices of sorghum demand high labor, biological researchers should consider labor-saving technologies for further studies.

The adoption level of improved management practices of sorghum is insufficient. Therefore, the improved management practices of sorghum should be promoted by raising the farm income of the household, organizing field day, incorporating the improved management practices in agricultural extension package development through the involvement of zonal, district, and kebele agricultural extension wing and extension and sorghum research teams.

Although the primary aim of sorghum producer farmers is grain yield while the applicability of the technology, the management of fertilizer, sorghum biomass, early maturity attributes should be considered at the time of the further study. Hence, the participation of farmers should be considered in further improved sorghum management practice research.

REFERENCE

Abubakar, M., Ibrahim, Y., Kado, D. and Bala, K. (2014). Contractors Perception of the Factors Affecting Building Information Modelling (BIM). *Computing in Civil and Building Engineering*, 167–178.

Ademe Mihiretu, Adane Wubets and Netsanet Asefa. (2019). Participatory evaluation of sorghum technologies in the marginal dryland zones of Wag-lasta, Ethiopia. *Cogent Food and Agriculture*, *1932*(5), 201–212.

Adesina, A. A. and Baidu-Forson, J. (1995). (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *Agricultural Economics*, *13*(1), 1–9.

Afework Hagos and Lemma Zemedu. (2015). Determinants of Improved Rice Varieties Adoption in Fogera District of Ethiopia. *American Journal of Ophthalmology*, *9*(3), 215–217.

Ajzen, I., and Fishbein, M. (1975). A Bayesian analysis of attribution processes. *Psychological Bulletin*, *82*(2), 261.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(50), 179–211.

Akalu Teshome, de Graaff, J., Ritsema, C. and Menale Kassie. (2014). Evaluation of soil and water conservation practices in the north-western Ethiopian highlands using multi-criteria analysis. *Land Degradation and Development*, *27*(4), 884–898.

Akalu Teshome, Graaff, J. De, Ritsema, C. and Menale Kassie. (2016). Farmers' perceptions about the influence of land quality land fragmentation and tenure systems on sustainable land management in the north western Ethiopian highlands. *Land Degradation and Development*, *10*(10), 1–15.

Almaz Giziew. (2008). *Adoption of Chickpea Technology Package in Adda and Akaki woredas, Eastern shewa, Ethiopia. An M. Sc Thesis Submitted to School of Graduate Studies, Haramaya University.*

Almaz Giziew and Begashaw Mebrate. (2019). *Determinants of the role of gender on adoption of row planting of tef [Eragrostis tef (Zucc .) Trotter] in central Ethiopia. Ethiopian Jornal ofr Science and Technology*. *12*(1), 19–43.

Aman Tufa and Tewodros Tefera. (2016). Determinants of Improved Barley Adoption Intensity in Malga District of Sidama Zone, Ethiopia. *International Journal of Agricultural Economics*, *1*(3), 78–83.

Asfaw, D. and Neka, M. (2017). Factors affecting adoption of soil and water conservation practices: The case of Wereillu Woreda (District), South Wollo Zone, Amhara Region, Ethiopia. *International Soil and Water Conservation Research*, *5*(4), 273–279.

Audilakshmi, S., Mall, A. K., Swarnalatha, M., and Seetharama, N. (2010). Inheritance of sugar concentration in stalk (brix), sucrose content, stalk and juice yield in sorghum. *Biomass and Bioenergy*.

Ayalew Worku. (2019). Factors Affecting Diffusion and Adoption of Agricultural Innovations among Farmers in Ethiopia Case Study of Ormia Regional State Westsern Shewa. *International Journal of Research Studies in Agricultural Sciences*, *5*(9), 27–36.

Bandura, A. (2001). S OCIAL C OGNITIVE T HEORY : An Agentic. *Annu. Rev. Psychol.*, *21*, 331–343.

Bank, W. (2019). *GDP share of agriculture in Ethiopia*.

Bartlett II, J. E., Kotrlik, J. W. and Higgins, C. C. (2001). Determing appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, *19*(1), 43–50.

Bekele Wegi. (2020). Determinants of agricultural technology adoption in Ethiopia: A meta-analysis. *Cogent Food and Agriculture*, *6*(1), 1–11.

Belay Kassa. (2003). Agricultural extension in Ethiopia: The case of participatory demonstration and training extension system. *Journal of Social Development in Africa*, *18*(1), 49–84.

Berhanu Fentie and Mesfin Fenta. (2021). Participatory on farm evaluation of improved sorghum varieties in North Gondar areas of Ethiopia. *Cogent Food and Agriculture*, *7*(1), 1871809.

Berihun Kassa. (2014). Adoption and Impact of Agricultural Technologies on Farm Income: Evidence From Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, *2*(4), 91–106.

Berihun Kassa. (2019). Determinants of adoption of improved sorghum package in agro-pastoral households of Somali Region of Ethiopia: A gender perspective. *Journal of Agricultural Extension and Rural Development*, *11*(11), 192–199.

Berihun Kassa, Bihon Kassa and Kibrom Aregawi. (2014). Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, *2*(4), 91–106.

Bernstein, M. and Putnam, W. (1986). Development, reliability, and validity of a dissociation scale. *The Jornal of Nervous Mental Disease.*, *174*(12).

Bezabih Emana and Hadera Gebremedhin. (2007). Constraints and opportunities of horticulture production and marketing in Eastern Ethiopia. *Dry Land Coordination Group*, *2*(DCG Report No. 46), 35.

Bradburn, N. M. (2010). Recall Period in Consumer Expenditure Surveys Program. *Bureau of Labor Statistics Consumer Expenditure Survey Methods Workshop – Papers and Presentations*, *1*(3), 1–13.

Broadbent, D. E. (1958). *The effects of noise on behaviour.*

Bruinsma, J. (2017). World agriculture: Towards 2015/2030: An FAO Study. *AN FAO PERSPECTIVE*, 1–431.

Cantril, H. and Allport, G. W. (1935). The psychology of radio. *The Routledge Handbook Of Adoption*, 120–134.

Cappellari, L. and Jenkins, S. P. (2003). *Multivariate probit regression using simulated maximum likelihood*. *3*, 278–294.

Cavatassi, R., Lipper, L. and Narloch, U. (2011). Modern variety adoption and risk management in drought-prone areas: Insights from the sorghum farmers of eastern Ethiopia. *Agricultural Economics*, *42*(3), 279–292.

Chemeda Birhanu. (2018). Sorghum [Sorghum bicolor L .] Breeding in Ethiopia : Review. *Journal of Biology, Agriculture and Healthcare*, *8*(21), 81–94.

Chilot Yirga and Hassan, R. M. (2013). Determinants of inorganic fertiliser use in the mixed crop_livestock farming systems of central highlands of ethiopia. *African Crop Science Journal*, *21*(3), 669–681.

Cole, E. S. and Donely, K. S. (1990). History Values, and Placement Policy Issues in Adoption in D. Brodzinsky and M. Schechter (Eds.), The Psychology of Adoption. *The Psychology of Adoption*, *21*(2), 273–294.

CSA. (2021). *The Federal Democratic Republic of Ethiopia Centeral Statistical Agency Agricultural Sample Survey 2017/18 (2010 E.C.): Report on area and production for major crops (private peasant holdings, Meher season). Ethiopia*. *I*, 57.

Deressa, T., Hassan, R. M., Alemu, T., Yesuf, M. and Ringler, C. (2008). Analyzing the determinants of farmers ' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. Discussion paper 00798. International Food Policy Research Institute, Washington DC. *International Food Policy Research Institute*.

Dooley, K. E. (1999). Towards a holistic model for the diffusion of educational technologies: An integrative review of educational innovation studies. *Educational Technology and Society*, *2*(4), 52–66.

EDHS. (2016). *(Ethiopian Demographic and Health Survey). Ethiopian demographic and health survey, Adiss Ababa, Ethiopia*.

Egge, M., Tongdeelert, P. and Rangsipah, S. (2010). Factors influencing the adoption of improved sorghum varieties in Awbere district of Somali regional state, Ethiopia. *East*

African Journal of Sciences, *4*(1), 41–47.

Elbaloula, M. F., Yang, R., Guo, Q. and Gu, Z. (2014). Major nutrient compositions and functional properties of sorghum flour at 0-3 days of grain germination. *International Journal of Food Sciences and Nutrition*, *65*(1), 48–52.

Elgar, E. (1998). *Expected utility theory, Cheltnham,UK. Northampton, MA,USA*.

Elsan, J. (2010). Bibliometric Analysis. In *Handbook of Disease Burdens and Quality of Life Measures*.

Ermias Tesfaye. (2013). *Adoption of improved sorghum varieties and farmers' varietal trait preference in Kobo district, North Wolo Zone, Ethiopia. M.Sc Thesis, Haramaya University, Ethiopia*. 137pp.

Ertiban Wondifraw, Muuz Gebretsadik, Sisay Ambachew and Melkie Desalegni. (2017). Dry and wet spells and ridging tied-ridging of vertisol effect on sorghum yield and soil moisture variability, North Gondar, Ethiopia. *Nile Water Science and Engineering*, *10*(2), 65–85.

FAO. (2018). Annex, S. OECD-FAO agricultural outlook 2021-2030. Korea, 1, 0-6. In *Pneumologie*.

Farid, K., Tanny, N. and Sarma, P. (2016). Factors affecting adoption of improved farm practices by the farmers of Northern Bangladesh. *Journal of the Bangladesh Agricultural University*, *13*(2), 291–298.

Feder, G., Just, R. E. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries. *A Survey. Economic Development and Cultural Change*, *33*(2), 255–298.

Feder, J. and Jossang, T. (1985). Viscous fingering fractals in porous media. *Physical Review Letters*, *55*(24), 26–88.

Feder, G., E, J. R. and David, Z. (1985). *Adoption of Agricultural Innovations in Developing Countries.Division of Agricultural Sciences university of California*. *225*, 1–121.

Feder, G. and O'Mara, G. T. (1982). On Information and Innovation Diffusion: A Bayesian Approach. *American Journal of Agricultural Economics*, *64*(1), 145–147.

Felix, M. T., Tewodros, T. and Wales, S. (2018). Perceptions and choices of adaptation measures for climate change among teff (Eragrostis tef) farmers of Southeast Tigray, Ethiopia. *Journal of Agricultural Extension and Rural Development*, *10*(1), 11–19.

Fliegel, F. F. and Kivlin, J. E. (1966a). *Farmers' perceptions of farm practice attributes. Rural Sociology, 31(2), 197.*

Fliegel, F. F. and Kivlin, J. E. (1966b). Farmers' perceptions of farm practice attributes. *Rural Sociology*, *31*(2), 197.

Garrity, D., Dixon, J., and Boffa Jean-Marc. (2012). Understanding African Farming Systems, Science and Policy Implications. *Food Security in Africa: Bridging Research and Practice*, *9*(3), 1–55.

Gebre, G. G., Isoda, H., Rahut, D. B., Amekawa, Y. and Nomura, H. (2019). Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia. *Women's Studies International Forum*, *76*(2), 1–14.

Gedefaw Abebe and Sisay Debebe. (2019). Factors affecting use of organic fertilizer among smallholder farmers in Sekela district of Amhara region , Northwestern Ethiopia. *Cogent Food and Agriculture*, *23*(5), 2331–1932.

Gibbons, R. D. and Hedeker, D. (2000). Factors affecting adoption of upland rice in Telemt district , northern Ethiopia. *Jornal of Statistices*, *62*(1), 70–103.

Goodhue, D. L. and Thompson, R. L. (1995). *Task-technology fit and individual performance*.
GZAO. (2021). *Gondar Zuria Agricultural office cereal report*.

Hadush Hagos, Ndemo, E. and Jemal Yosuf. (2018). Factors affecting adoption of upland rice in Tselemti district , northern Ethiopia. *Agriculture and Food Security*, *59*(7), 1–9.

Hailegebrial Kinfe and Adane Tesfaye. (2018). Yield Performance and Adoption of Released

Sorghum Varieties in Ethiopia. *Edelweiss Applied Science and Technology*, *2*(1), 46–55.

Haileslasie Gereziher and Gidey Kidu. (2021). Estimating the impact of inorganic fertilizer adoption on sesame productivity: evidence from Humera, Ethiopia. *Cogent Food and Agriculture*, *7*(1), 1–14.

Hanibal Lemma and Hanibal Lemma. (2015). Demonstration and evaluation of water harvesting and supplementary irrigation to improve agricultural productivity. In *Mitigating Land Degradation and Improving Livelihoods: An Integrated Watershed Approach*.

Havens, A. E. and Rogers, E. M. (1961). Adoption of hybrid corn: profitability and the interaction effect. *Jornal of Rural Sociology*, *26*(4), 409.

Hirut Haile. (2008). *The Effect of Targeting Credit to Married Women on Intra-household Expenditure Roles in Ethiopia: Paper Prepared for The Brisbane International Feminist Conference, 3rd to 5th September, 2008 South Brisbane, Queensland, Australia*.

Israel, N. D. (2003). Determination of sample size. *Malaysian Journal of Medical Sciences*, *10*(2), 84–86.

Jafer Mume and Aman Kemal. (2014). Factor affecting rain-water-harvesting technology adoption and farmers practices against drought and water shortage in Eastern Hararghe low land, Ethiopia. *International Journal of Agricultural Science, Research and Technology in Extension and Education Systems*, *4*(2), 105–114.

Jeffrey Pickens. (1985). *Attitudes and Perceptions, Cahpter three, Later Life Transitions, St. Thomas University in Miami, Florida.* 123–136.

Kebebe Ergano. (2015). *Understanding factors affecting technology adoption in smallholder livestock production systems in Ethiopia: the role of farm resources and the enabling environment.*

Kinyangi, A. A. (2014). *Factors influencing the adoption of agricultural technology among smallholder farmers in Kakamega North sub-county. MSc Thesis, University of Nirobi, Kenya*. 77pp.

Kivlin, J. E. (1998). Characterstics of Farm Practices Associated with Rate of adeoption.Journal of Allergy and Clinical Immunology. PhD. thesis, Pennsylavania state University, Michigan. *Journal of Allergy and Clinical Immunology.*, *130*(2), 556.

Krusiewicz, E. S. and Wood, J. T. (2001). entrance stories of adoptive parents. *Journal of Social and Personal Relationships*, *18*(6), 785–803.

Lauterbach, S. (2000). Handbuch Translation. *Informationen Deutsch Als Fremdsprache*, *27*(2–3), 312–315. https://doi.org/10.1515/infodaf-2000-2-3100

Le, K. and Tam, V. (2007). To enhance student learning. *Decision Sciences Journal of Innovative Education*, *5*(1), 1–19.

Liska, A. E. (1984). A critical examination of the causal structure of the Fishbein/Ajzen attitude-behavior model. *Social Psychology Quarterly*, *1*(3), 61–74.

Loevinsohn, M., Sumberg, J., Diagne, A. and Whitfield, S. (2013). *Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? Institute of Development Studies, Brighton, UK*. *2*, 1–38.

Mawusi, E. (2004). *Farmers ' Knowledge and Perception towards a Sustainable Adoption of Sugar Beet in Kenya. Lund University,Sweden*. 47 pp.

Mcendoo, J. (1989). *A Comparison of Two Theoretical Models*.

McGuire, E., Cast, A. D. and Morton, W. (2012). Reconstructing the good farmer identity: shifts in farmer identities and farm management practices to improve water quality. *Computers and Electronics in Agriculture*, *87*(3), 121–128.

Menasbo Gebru. (2020). Does fertilizer adoption enhance smallholders' commercialization? An endogenous switching regression model from northern Ethiopia. *Agriculture and Food Security*, *9*(3), 1–18.

Menasbo Gebru. (2021). The impact of participation in rural credit program on adoption of inorganic fertilizer: A panel data evidence from Northern Ethiopia. *Cogent Food and*

Agriculture, *7*(1), 1919388.

Mesfin Fenta. (2017). *Adoption of improved chickpea technologies in North Gondar zone of Ethiopia: The case of Gondar Zuria district. M.Sc Thesis, University of Gondar, Ethiopia*. 117 pp.

Miah, M. A. M., Afroz, S., Rashid, M. A. and Shiblee, S. A. M. (2016). Factors Affecting Adoption of Improved Sesame Technologies in Some Selected Areas in Bangladesh: An Empirical Study. *A Scientific Journal of Krishi Foundation*, *13*(1), 140–151.

Mideksa Dabessa, Moti Jaleta and Fikadu Mitiku. (2021). Determinants and profitability of inorganic fertilizer use in smallholder maize production in Ethiopia. *Cogent Food and Agriculture*, *7*(1), 91–121.

Miller, N. E. and Dollard, J. (1941). *Social learning and imitation.New Haven, CT: Yale University Press.*

Miller, R. L. (2015). Rogers' innovation diffusion theory (1962, 1995). In Information seeking behavior and technology adoption: Theories and trends (pp. 261-274). IGI Global. *Nurse Education Today*.

MOA. (2014). *National strategy for Ethiopia's agricultural extension system vision, systemic bottlenecks and priority interventions annual report. Ethiopia*.

Mongin, P. (1998). Utility Theory and Ethics. In *Handbook of Utility Theory, Volume 1: Principles* (pp. 371–481).

Monu, E. D. (1997). Farmer participation in research: Implications for agricultural development. *Journal of Social Development in Africa*, *12*(1), 53–66.

Muhammed Shako, Mosisa Waktola and Dinku Adunea. (2020). Determinants of adoption of agricultural extension package technologies by smallholder households on sorghum production: Case of Gemechis and Mieso districts of West Hararghe Zone, Oromia Regional State, Ethiopia. *Journal of Agricultural Extension and Rural Development*, *12*(3), 62–75.

Negera Eba and Getachew Bashargo. (2014). Factors affecting adoption of chemical fertilizer by smallholder farmers in Guto Gida district, Oromia regional state, Ethiopia. *Science, Technology and Arts Research Journal*, *3*(2), 237.

Negese Tamirat, Jemal Abafita and Endeg Wolde. (2017). *Household Livelihood: a case of adoption and impact of row planting of wheat crop on household livelihood at Duna woreda in Hadiya zone , Ethiopia* . *1*(2), 1–22.

Negussie Siyum. (2019). *Adoption of bread wheat technology packages: a case of meket district in North Wollo zone of Amhara region, Ethiopia. M.Sc Thesis, Bahirdar University, Ethiopia*. 90 pp.

Neseni, R. V., Flade, E., Heidler, G. and Steger, H. (1958). *Milchleistung und Milchzusammensetzung von Stuten im Verlaufe der Laktation. Arch. Tierz, 1, 91-129.*

Nijs, L. (2014). Challenges in Agricultural Production and Natural-Resources Management. *In The Handbook of Global Agricultural Markets*, *11*(3), 289–302.

Ogada, D. L. (2014). The power of poison: Pesticide poisoning of Africa's wildlife. *Annals of the New York Academy of Sciences*, *1322*(1), 1–20.

Petros Admasu, Woldeab Berihun and Ayalew Niguse. (2014). Prevalence of Bovine Tuberculosis in Dairy Cattle of Yeki District , Southern Ethiopia. *African Journal of Basic and Applied Sciences*, *6*(5), 135–140.

Prasad, P. V. V., and Staggenborg, S. A. (2011). *Growth and production of sorghum and millets. soils, plant growth and crop production*. *2*, 1–27.

Rogers. (1983). *The nature of engineering: a philosophy of technology. Macmillan International Higher Education.* 469–479.

Rogers. (2003). *Diffusion of Innovations. 5th edn New York, NY.*

Rogers, E. M. (1995a). *Diffusion of innovation, 4 th edition. New York: Free Press.*

Rogers, E. M. (1995b). *Lessons for guidelines from the diffusion of innovations. The Joint Commission journal on quality improvement, 21(7), 324-328.* https://doi.org/10.1016/j.worlddev.2014.01.024

Rogers E.M. (1962). *Diffusion of innovations. New York, USA: Free Press of Glencoe, pp*. 136–142.

Rubin, D. L. and Smith, K. A. (1990). Effects of accent, ethnicity, and lecture topic on undergraduates' perceptions of nonnative English-speaking teaching assistants. *International Journal of Intercultural Relations*, *14*(3), 337–353.

Russakovsky, O., Deng, J., Su, H., Krause, J., Satheesh, S., Ma, S., Huang, Z., Karpathy, A., Khosla, A., Bernstein, M., Berg, A. C. and Fei-Fei, L. (2015). ImageNet Large Scale Visual Recognition Challenge. *International Journal of Computer Vision*, *115*(3), 211–252.

Sahin, A., Guvenc, I. and Arslan, H. (2014). A survey on multicarrier communications: Prototype filters, lattice structures, and implementation aspects. *IEEE Communications Surveys and Tutorials*, *16*(3), 1312–1338.

Shakya, P. B. and Flinn, J. C. (1985). Adoption of modern varieties and fertilizer use on rice in the Eastern Tarai of Nepal. *Journal of Agricultural Economics*, *36*(3), 409–419.

Sharma, R. and Mishra, R. (2014). *Review on evolution of theories and models of technology adoption. Indore Management Journal, 6(2), 17-29.*

Sharp, R., Yue, Y., Han, J., Han, G., Aita, G. M., Wu, Q., ALBERTINI, S., CARMO, L. F. DO, PRADO FILHO, L. G. DO, Costa, L. A. D. S., Fonseca, A. F., Pereira, F. V., Druzian, J. I., Khalil, H. P. S. A., Davoudpour, Y., Islam, N., Mustapha, A., Sudesh, K., Dungani, R., … Rainey, T. J. (2016). *Farmers' Perception of Agricultural Extension Service Delivery in Germiston Region, Gauteng Province, South Africa*. *17*(1), 1–13.

Sherif, M. and Cantril, H. (1945). *The psychology of'attitudes': Part I. Psychological Review, 52(6), 295.*

Silamlak Birhanu and Faris Hailu. (2021). Farmers' Perception about the Use of Sorghum (Sorghum bicolor (L.) Moench) Landraces and Their Genetic Erosion in South Wollo

Administrative Zone, Ethiopia. *International Journal of Agronomy*, *3*(1), 1–14.

Simachew Yedemie and Yonas Worku. (2018). Promotion of improved management of sorghum for small scale farmers in North Gondar, Gondar Zuria district. *Modern Concepts and Developments in Agronomy*, *2*(2), 128–130.

Simtowe, F., Menale Kassie, Diagne, A., Solomon Asfaw, Bekele Shiferaw, Silim, S. and Muange, E. (2011). Determinants of agricultural technology adoption: The case of improved pigeonpea varieties in tanzania. *Quarterly Journal of International Agriculture*, *50*(4), 325–345.

Singh, C., Osbahr, H. and Dorward, P. (2018). The implications of rural perceptions of water scarcity on differential adaptation behaviour in Rajasthan, India. *Regional Environmental Change*, *18*(8), 2417–2432.

Solomon Asfaw, Bekele Shiferaw, Franklin Simtowe and Messia Hagos. (2011). Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. *Journal of Development and Agricultural Economics*, *3*(9), 436–447.

Surry, D. W. (1977). Diffusion Theory and Instructional. *Educational Communications and Technology (AECT)*, *3*(3), 1–14.

Swearer, S. M., Wang, C., Berry, B. and Myers, Z. R. (2014). Reducing Bullying: Application of Social Cognitive Theory. *Theory into Practice*, *53*(4), 271–277.

Taylor, S. and Todd, P. A. (1995). Understanding information technology usage.pdf.crdownload.pdf. In *Information Systems Research* (Vol. 6, Issue 2, pp. 144–176).

Teame Hailemariam. (2011). Factors determining fertilizer adoption of the peasant farm sector in northern ethiopia , tigray region. *Jornal of Life Sciences*, *1*(3), 338–395.

Teshome, A., de Graaff, J. and Kassie, M. (2016). Household-Level Determinants of Soil and Water Conservation Adoption Phases: Evidence from North-Western Ethiopian Highlands. *Environmental Management*, *57*(3), 620–636.

Teshome, S. and Tegegne, B. (2020). Determinants of Adoption of Improved Teff Varieties by Smallholder Farmers: The Case of Kobo District, North Wollo Zone, Amhara Region, Ethiopia. *International Journal of Agricultural Economics*, *5*(4), 114.

Tewodros Tefera, Girmay Tesfay, Eyasu Elias, Mulugeta Diro and Irene Koomen. (2016). Drivers for adoption of agricultural technologies and practices in Ethiopia. *16th International Conference on the Ethiopian Economy, Addis Ababa, Ethiopia*.

Timu, A. G., Mulwa, R., Okello, J. and Kamau, M. (2014). The role of varietal attributes on adoption of improved seed varieties: the case of sorghum in Kenya. *Agriculture and Food Security*, *3*(1), 1–7.

Trafimow, D. (2009). The Theory of Reasoned Action. In *Theory and Psychology* (Vol. 19, Issue 4, pp. 501–518).

Venkatesh, V. and Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273–315.

Venkatesh, V. and Davis, F. D. (2000). Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems*, *27*(3), 425–478.

Weiner, B. (1988). *Attribution theory and attributional therapy : Some theoretical observations and suggestions* (pp. 93–104).

Yamane, T. (1967). *Statistics: An Introductory Analysis. Second edition.Harper and Row. New York, 919.*

Yirssaw Demeke, A. (2019). Analysis of factors affecting the demand for inorganic fertilizer in Boricha and Wondogenet Districts, Southern Ethiopia. *African Journal of Agricultural Research*, *14*(10), 609–616.

Yitayal Abebe and Adam Bekele. (2014). The Impact of Soil and Water Conservation Program on the Income and Productivity of Farm Households in Adama District, Ethiopia. *Science, Technology and Arts Research Journal, 3*(3), 198.

Yohannes Kebede, Y., Gunjal, K., and Coffin, G. (1990). Adoption of New Technologies in Ethiopian Agriculture: The Case of Tegulet-Bulga District, Shoa Province. *Journal of Agricultural Economics, 4*(1), 27–43.

Yonas Worku, Simachew Yedemie, Eshetu Melesse and Biyadgie Wubie. (2018). Pre- extension demonstration of improved sorghum management in Gondar Zuria district. *Amhara Regional Agricultural Research Institute Workshop Proceedings of 6-17 March 2017 and 30 April – 04 May 2018 Bahir Dar, Ethiopia, June 2020*.

Zebib Kassahune. (2014). *Constrains and adoption of technologies introduced through the eco-farm project in Ethiopia, Doctoral dissertation, Master Thesis, Norwegian University of Life Sciences Faculty of Social Science.*

Zegeye, T., Taye, G., Tanner, D., Verkuijl, H., Agidie, A. and Mwangi, W. (2001). Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-scale Farmers in Yelmana Densa and Farta Districts of Northwestern Ethiopia. In *Ethiopian Agricultural Research Organization (EARO)* (Issue June).

APPENDICES

Appendix Table 1.Tropical livestock unit Conversion factor (TLU)

Livestock category	Conversation factors
Calf	0.25
Heifer/Bull	0.75
Cow	1
Ox	1
Horse/Mule	1.1
Donkey/ adult	0.7
Camel	1.25
Sheep/Goat	0.13
Chicken	0.013

Source: Storck *et al* .(1991)

Appendix Table 2. The conversion facto used to compute man-days equivalent

Age group in year	Male	Female
< 10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1	0.8
>50	0.7	0.5

Source: Storck *et al* .(1991)

Appendix Table 3. Multi-collinearity tes1. Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

Chi2 (1)	34.7
Prob> chi2	0.000

Appendix Table 4. Multi-collinearity tes2. Omitted variable test using Ramsey RESET

Model has no omitted variables	F(3, 195) =	4.41
Variables	Prob> F =	0.0050

Appendix Table 5. Multi-collinearity test by a variance inflation factor (VIF)

Variables	VIF	1/VIF
Age of the respondent	7.46	0.134072
Farming experience of the respondent	7.35	0.136096
Training participation	1.90	0.527217
Farm income	1.61	0.621450
Total family size	1.54	0.648628
Credit access	1.52	0.659709
Total land holding	1.50	0.665678
Education level of the respondent	1.47	0.680967
Field day participation	1.45	0.687416
TLU	1.30	0.771092
Labor access	1.28	0.779991
Family membership to the cooperative	1.28	0.783376
Non-farm income	1.26	0.792326
Household asset	1.25	0.797985
Sex of the household respondent head	1.25	0.801194
Mean VIF	2.23	

Appendix Table 6. Collinearity statistics for variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Farming experience (1)	**1**														
Total family size (2)	0.23	**1**													
Respondent age (3)	0.92	0.25	**1**												
Respondent sex (4)	0.04	0.04	0.12	**1**											
Education level (5)	-0.03	0.25	-0.01	0	**1**										
Total landholding (6)	0.3	0.14	0.29	0.3	0.01	**1**									
Credit access (7)	0	0.22	0.02	0	0.4	-0.03	**1**								
Cooperative member(8)	-0.04	0.25	0	0.1	0.11	0.17	0.18	**1**							
Non-farm income (9)	-0.01	0.08	0	0.1	0.34	0.07	0.27	-0.02	**1**						
Farm income (10)	0.02	0.42	0.03	0.1	0.33	0.11	0.42	0.23	0.2	**1**					
Labor access (11)	-0.21	-0.21	-0.23	0.1	-0.08	-0.03	0.17	0.14	0.08	-0.02	**1**				
TLU (12)	0	0.21	0.05	0.2	0.19	0.29	0.12	0.11	0.12	0.23	-0.1	**1**			
Field day (13)	0.11	0.23	0.14	0.1	0.07	0.03	0.17	0.11	0.17	0.1	-0.1	0.2	**1**		
Household asset (14)	0.11	0.21	0.17	0	0.24	0.15	0.14	0.06	0.15	0.21	-0.1	0.23	0.14	**1**	
Training (15)	0.1	0.39	0.13	-0	0.15	-0.07	0.2	0.23	0.17	0.36	-0.1	0.25	0.49	0.29	**1**

2. Interview Schedule

I am an employee of Gondar Agricultural Research on Sorghum Improved Management Practices in Gondar Zuria district. We have selected households in the Gondar Zuria district in the Amhara region to talk to themes regarding farmer's perception towards sorghum improved management practices, to identify factors affecting sorghum improved management practices, and to determine the level of sorghum improved management adoption. You are one of these randomly selected households and we would be very grateful if you could sit with us and have a discussion. The information generated in this study will be kept in a secure place and will be used only for this research.

Thank you for your willingness to participate in this study, just to emphasize, any answers you provide be kept confidential and there is no way anyone will be able to identify you by what you have said in this interview. You have the right to terminate this interview at any time, and you have the right to refuse to answer any question you might not want to respond to.

Note

1. The question may have more than one answer. Use a comma to separate multiple responses when applicable.
2. Years and seasons are all in the Ethiopian calendar.

Use either Amharic or English language. Please do not use other languages.

Section 1. Household Identification

1. Name of the household head ……ID…….. Enumerator ID……
2. Kebele……. Village ….....
3. Phone Number/Mobile……..

Section 2.Demographic characteristics of the Household head

2.1.Total family size ……. 1. Age < 15…… 2. Age 16 – 64……3. Age > 64……

2.2.Respondent age……

2.3. Sex 1. Male 2. Female

2.4. Education level 1. Literate 2. Illiterate

If literate, Primary school (1-8) 2.High school (9-10).Preparatory (11-12). 3. 10+3 and above

2.5.Marital status of the household heads. 1. Married 2. Single 3. Divorced 4. Widowed

2.6. Farming experience ……years.

2.7. Landholding

Land allocation	Land size / timad	Number of plot
Total own land		
covered with sorghum		

Section 3. Access to infrastructure

Subsection 3.1: Access to infrastructure		
	Infrastructure	Walking inMinute
1	How far is the nearest main market from your residence?	
2	How far is the source of fertilizer from your residence?	
3	How far are farmers multi-purpose primary cooperative from your residence?	
5	How far Farmers' training center (FTC) from your residence?	
6	How far is the nearest Health Center from your residence?	
7	How far is the nearest School from your residence?	

Section 4. Access to Household Asset

	Asset	How many [….] do you have in the household?	What is the current market price of your [….]? Take average price...birr
1	Animal scotch cart		
3	Horse/mule cart		
4	Mobile phone		
5	Grain mill		
6	Ox-plough set		
7	Radio		
8	Television		
9	Corrugated iron sheet		
10	Other plowing material		

Section 5. Sorghum improved management practices usage

1	Have you ever applied fertilizer/UREA for sorghum during the last five years?	1= yes 0 = no	
2	Do you remember when you applied fertilizer /**UREA**for the first time?	1= yes, when …… ……. 0 = no	
3	Have you been applying fertilizer/ **UREA** for sorghum continuously since you first applied it? 3.1. If yes for how many yrs. …..?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
4	Where did you know the fertilizer/**UREA** importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6=University 7= Others
5	Have you ever applied fertilizer/**NPS**for sorghum during the last five years?	1= yes 0 = no	
6	Do you remember when you applied fertilizer /**NPS**for the first time?	1= yes, when …… ……. 0 = no	
7	Have you been applying fertilizer/ **NPS** for sorghum continuously since you first applied it? If yes for how many yrs. …..?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
8	Where did you know the fertilizer/**NPS** importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6=University 7= Others

9	Have you ever applied row planting for sorghum during the last five years?	1 = yes 0 = no If no, why……	
10	Do you remember when you applied row-planting methods for the first time?	1 = yes, when…….. 0 = no	
11	Have you been applying row-planting methods for sorghum continuously since you first applied it? 7.1. If yes for how many yrs. ……?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
12	Where did you know the row-planting methods for sorghum importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6= University 7= Others
13	Have you ever practiced thinning for sorghum during the last five years?	1 = yes 0 = no	
14	Do you remember when you practiced thinning for the first time?	1 = yes, when…….. 0 = no	
15	Have you been thinning for sorghum continuously since you first applied it? If yes for how many yrs. ….....?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
16	Where did you know thinning practice for sorghum importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6= University 7= Others
17	Have you ever practiced weeding for sorghum during the last five years?	1 = yes 0 = no	
18	Do you remember when you practiced weeding for the first time?	1 = yes, when…….. 0 = no	
19	Have you been weeding for sorghum continuously since you first applied it? 15.1. If yes for how many yrs. ……?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
20	Where did you know weeding practice for sorghum importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6= University 7= Others
21	Have you ever done ridge for sorghum	1 = yes 0 = no	

	during the last five years?		
22	Do you remember when you done ridge for the first time?	1 = yes, when…….. 0 = no	
23	Have you been applying ridge for sorghum continuously since you first applied it? 19.1. If yes for how many yrs. ……?	1 = yes 0 = no, if the response is "no" why? 1…….. 2……. 3……..	
24	Where did you know ridge practice for sorghum importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center 4 = cooperative	5= NGOs 6= University 7= Others
25	Have you ever done tie- ridge for sorghum during the last five years?	1 = yes 0 = no	
26	Do you remember when you were done tie-ridge for the first time?	1 = yes, when…….. 0 = no	
27	Have you been applying tie- ridge for sorghum continuously since you first applied it? 23.1. If yes for how many yrs. ……?	1 = yes 0 = no, if the response is "no" why? 1…….. 2…….. 3……..	
28	Where did you know tie-ridge practice for sorghum importance?	1= Neighbor and Relative 2= Office of agriculture 3= Research center	5= NGOs 6= University 7= Others

Section 6. In 2012/2013E.Ccropping season Sorghum improved management practices on each plot

		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
	Plot area in /kada/timad							
	Sorghum /area/							
1	Land covered by row planting (kada /timad)							
2	Land covered by recommended Fertilizer(kada /timad) 139 urea/ha and 121 kg NPS/ha							
3	Land covered by ridge (kada /timad)							
4	Land covered by tie-ridge (kada/timad)							
5	Land covered by thining (kada /timad)							
6	Land covered by Weeding (kada /timad)							

7	Sorghum yield of improved management(kg)							
8	Sorghum yield of local practice (kg)							
9	Total yield of for all sorghum (kg)							
10	Total yield of others crop on the plot (kg)							

NB. OC indicates that 'other crops' which are produced in the plot.

Section 7. Access to credit

11	Have you faced critical shortage of money for agricultural activities?	1=Yes 0 = No
12	Did you receive any credit in the last 12 months?	1=Yes 0 = No

Let's discuss about the types, quantity, and source of the credits you acquired

	Did you receive…?	Source Code…A	Quantity (unit)
1	Cash loan		
2	Agricultural input loan		

CODE A: 1 = Bank, 2= Local lender, 3= Neighbor farmers , 4 = NGO, 5 = Gov., 6 = Relatives and friends , 7= Saving and credit, 8= edir, 9 = Other

Section 8. Social Capital and Networking

Membership of the household in formal and informal organization

	Name of the org.	Is anyone in the family a member of …? 1 = yes 0 = no	Who is the member? 1= Husband 2=Wife 3= Children 4= Husband and wife 5=All
1	Multi-purpose coop.		
2	1 to 5 organization		
3	Development army		
4	Local administration		
5	Saving and credit association		
6	Seed multiplication group		
7	Edir		
8	Mahiber		

Section 9.Livestock Ownership

Livestock type	Oxen	cows	Heifers	Bull	calves	donkey	Mule	horses	goats	sheep	Chicken	Bee hives	
												Modern	local
How many current owned …?													

Selling price													

Section 10. Access to Agricultural Services

Agricultural Extension service				
Let's discuss the agriculture related interactions you have had over the last 12 months:				
	Source	How many field days attended organized by […] ?	Did you discuss about cereal crops? 1 = Yes 0=No	How many sorghum related trainings attended [...]?
1	Agr. Ext. service			
2	Agr. Research service			
3	Farmer Cooperatives			
4	model farmers plot			
5	NGO			
	Types of Activity		Participation/year	If you get ….With whom CODE L
1	On farm demonstration			
2	Frequency of Extension contact			
3	Field day			
4	Pre-scaling up/ clustering approach			
CODE L 1 = Development agents, 2 = Agricultural Research center, 3 = University, 4 = NGO, 5 = Others ……specify it				

Section 11. Access to market

	Commodity	Did you get market information before you grow…?		Did you get market information before you sell …?	
		Yes =1 No =0	If Yes, source? CODE A	Yes =1 No =0	If Yes, source? CODE A
	Sorghum				
	Other crops				
CODE A 1= Government extension service 4= Neighbor farmers 7= Markets 2= Government Research center 5= Seed traders 8= radio/ television 3=Farmers cooperatives 6= NGOs 9= Mobile 10= Others					

Section 12. Section Income

Non-farm/off farm activities

1.1 Do you involve in off/non- farm activities? 1. Yes, 2. No

1.2. If Yes, type of off, non-farm activities, and their contribution for monthly income

No	Activities	Average monthly income in birr
1	Petty trade	
2	Salary employment	
3	Handcraft	
4	Grain and livestock trade	
5	Charcoal making	
6	Casual labor	
7	Remittance	
8	Others	

Section 12.2. Farm income

	Commodity	Amount of Sold/ birr	Amount of consumed
1	Crops/livestock/ fruits/ vegeTable/ per. Crops		

Section 13. Availability of Labor

1. Do you face a labor shortage for chickpea production? 1= Yes 2= No
2. If yes, for which operation/s? 1= plowing 2= planting 3= weeding 4= harvesting 5= other, specify
3. How do you overcome the labor shortage? 1= Wobera 2= Debait 3= hired labor 4= other, specify
4. If you hired labor last year for chickpea production, how many working days?_____
5. Can you easily get the labor to hire whenever you need it? 1= Yes, easily 2= Yes, but sometimes with difficulty 3= No
6. If No, why? 1= there is no labor market 2= I don't have the means to hire labor 3= other, specify?

Section 14. Farmer perception and preference towards sorghum-improved management

Sub-section 15.1. Farmer perception of fertilizer application for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	Fertilizer application					
1	For plant growth					
2	For yield increment					
3	Increase biomass					
4	Early maturity date					

Sub section 13.2. Farmer perception to row planting for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	Row planting					
1	easy management					
2	Reduce seed cost					
3	Proper fertilizer placement					
4	Yield increment					

Sub section 13.3… Farmer perception to thinning for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	Thinning					
1	Help to weed and pest management					
2	Helps to increase yield					
3	Important for fertilizer management					
4	Increase the biomass yield					

Sub Section 13.4. Farmer perception to weeding for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	Weeding					
1	important for plant growth					
2	Proper water utilization					
3	Important to reduce pest infestation					
4	Yield increment					

Sub Section 13.5. Farmer perception to riding for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	Ridging					
1	important for plant growth					
2	Easy for applicability					
3	Important to increase the yield					
4	Reduce waterlogging					

Sub Section 13.6. Farmer perception to tie riding for sorghum

1 = strongly disagree, 2 = disagree, 3 = neutral, 4. Agree, 5= strongly agree						
	tie riding					
1	important for plant growth					
2	Reduce runoff					
3	Important to increase the yield					
4	Important to conserve soil fertility					

What are the major challenges for sorghum improved management practices?

……
……

End