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FACTORS AFFECTING FARMERS' HIRING DECISION ON AGRICULTURAL MECHANIZATION SERVICES: A CASE STUDY IN DEBRE ELIAS WOREDA, EAST GOJAM ZONE, ETHIOPIA

BY

YOHANNES MEKONNEN TESEMA

JUNE 2021

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A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF AGRICULTURAL ECONOMICS

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APPROVED BY BOARD OF EXAMINERS

As members of board of examiners of the final MSc. thesis open defense, we certify that we have read and evaluated the thesis prepared by Yohannes Mekonnen under the title **"Factors Affecting Farmers' Hiring Decision on Agricultural Mechanization Services**". We recommend that this thesis to be accepted as fulfilling the thesis requirement for the degree of Master of Science in Agricultural Economics.

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DECLARATION

I, the undersigned, declare that this thesis is my original work; prepared under the guidance of Dr. Paulos Asrat. All the sources of materials used for this thesis have been dully acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

_____	_____
Name	Signature and Date

ENDORSEMENT

This thesis has been submitted to Saint Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

Paulos Asrat (PhD) _____

Advisor Signature and Date

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ACRONYMS

ASAE	American Society of Agricultural Engineers
ASABE	American Society of Agricultural and Biosystem Engineers
ATA	Agricultural Transformation Agency
CHC	Custom Hiring Company for Farm Machineries
CIMMYT	International Maize and Wheat Improvement Centre
CSA	Central Statistics Agency
DAT	Draft-Animal Technology
DAP	Diammonium Phosphate
ENAMS	Ethiopian National Agricultural Mechanization Strategy
EPT	Engine-Powered Technology
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FDRE	Federal Democratic Republic of Ethiopia
HTT	Hand-tool Technology
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IRRI	International Rice Research Institute
MoA	Ministry of Agriculture
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Program
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

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ABSTRACT

In Ethiopia, improving smallholder farmers' access to mechanization technologies through service provider scheme is being supported and promoted in the national agricultural mechanization strategy of the country. Although the use of agricultural mechanization has been increasing in the past years, hiring of the service is still limited both in terms of the types of mechanization technologies and the geographical coverage. Different factors affect the hiring decision of smallholder farmers. Thus, the main objective of this research was to analyze the factors influencing smallholder farmers' decision on hiring tractor and/or combine harvester mechanization services. The study was carried out in 2020/21 at Debre Elias woreda in East Gojam zone of the Amhara national regional state, Ethiopia. A formal survey which involved a two-stage sampling procedure was used to select farmers from three kebeles. Using random sample techniques, the study selected a total of 133 household farmers. Of which, 52 hired tractor ploughing service and 78 hired combine harvester service. Descriptive statistical tools were employed to analyze the level of usage of mechanization services. In addition, Binary Logistic Regression Analysis was applied to identify factors affecting the hiring decision of smallholder farmers for agricultural mechanization services. Results showed that the number of economically active labour force, number of oxen, land size, goal of farming, off-farm income, and institutional factors significantly affected farmers' tractor hiring decisions. The result also showed that factors like labour cost and weather uncertainty were statistically significant to influence the hiring decision of farmers' for combine harvesters. In the study area, mechanization services were mainly provided by private contractors. Based on the findings, government has a big role in influencing the hiring decision through its extension system. Financial credit must be made available for hiring mechanization services. To increase accessibility of mechanization technologies, government should provide incentives and subsidize the cost of acquiring machineries and equipment. Training and advise through the extension system as well as applying ICT to minimize the searching and timely availability of services are recommended.

Key words: Hiring tractor services; Hiring combine harvester; Farm machinery services;

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Agriculture is one of the cornerstones of the national economy of Ethiopia. According to UN, the population of Ethiopia is estimated at 117 million growing at 2.6 percent annually (UN, 2019). Producing adequate food for a rapidly growing population is a prime challenge. Traditionally, Ethiopian agriculture is low-input and low-output, leading to low crop productivity levels that are significantly below regional and international standards (ENAMS, 2014). The country's agricultural growth policy is geared towards increasing food production using improved technologies including improved seed of crop varieties, proper cultural practices, efficient irrigation systems and farm mechanization. Agricultural production has shown a steady growth (UNDP, 2011) overtime; however, the advancement largely comes from the expansion of farmland (IFPRI, 2010). Growth in cereal (maize, wheat, sorghum, barley, teff) production, for instance, has increased by 7 percent per year from 2000 to 2009 (Alemayehu S. et al., 2012). The use of modern inputs has doubled, driven by high government expenditures in the agriculture sector, including agricultural extension, and by improving road network, higher rural education levels, and favorable international and local price incentives. Despite these huge investments, the country cannot self-sufficient and is still one of the main grain importers in Africa (IFAD,2016).

In the highlands where crop production systems are predominant, smallholder farmers form the backbone of the agriculture sector, producing about 90-95 percent of the country's output. These farmers commonly employ backward production technologies and use limited modern inputs (World Bank, 2007). The existing traditional subsistent rain-fed agricultural production system cannot guarantee to feed the growing population. In Ethiopia, crop productivity per unit area of land remains very low due to various constraints including the limited use of appropriate productivity boosting technologies and appropriate crop production husbandry practices (FAO, 2019). Only 2 percent of the arable land of a smallholder is irrigated, and just 3.7 percent have access to agricultural machinery (FAO, 2017). Hence, being an agriculturally dependent country with a food deficit gap, increasing crop production and productivity is not a matter of choice rather a must. While agricultural mechanization has shown to be an effective way of increasing production, it so far has not experienced significant application or use in the Ethiopian smallholders' context (ENAMS, 2014).

Agricultural mechanization covers all levels of farming and processing technologies, from simple hand tool technology to hi-tech motorized equipment. Farm mechanization has been known to provide several economic and social benefits to farmers. Increased levels of farm power and mechanization is one of the major factors required to increase production. Studies have shown a direct relationship between farm mechanization (farm power availability) and farm yield. Due to farm mechanization there is 15-20 percent saving in inputs like seeds and fertilizers and increase in cropping intensity by 5-20 percent (Nikhade S., 2020).

Farm mechanizaiton also helps in increasing the efficiency of farm labour and reducing drudgery and workloads. It is estimated that farm mechanisation can help in reducing operational time by approximately 15-20 percent. Additionally, farm mechanization helps in improving the harvest, reducing the post-harvest losses and improving the quality of cultivation. These benefits and the savings in inputs help to minimize production costs and allow farmers to earn more income.

Among the various social benefits, farm mechanisation helps in conversion of uncultivable land to agricultural land through advanced tilling techniques and also in shifting land used for feed and fodder cultivation by draught animals towards food production. It can also help to maintain a decrease in workload on women as a direct consequence of the improved efficiency of labour. It is believed that drudgery of manual agricultural labor can make farming unattractive to youth and influences them to seek off-farm employment that can be potentially less productive (Merma et al, 2008). In this regard, it helps in encouraging the youth to join farming and attract more people in the agricultural business.

The agriculture sector in Ethiopia has depended for long time on cheap and surplus labour. One of the stated reasons behind sufficient supply of such labour was lack of opportunities. However, the situation is now changing due to rapid urbanization. Migration to the urban areas as well as increased employent opportunities in non-farm services in the rural areas could create pressure on rural wages (Byerlee, 1974). The migration trend has been consistent with a growing economy and growth of infrastructure. Ethiopia is one of countries with higher rate of urbanization (4.3 percent) as well as rapidly increasing urban centers (Demese, 2007:85 cited in FAO et al, 2017).

In Ethiopia, the level of use of agricultural mechanization greatly varies among regions. Arsi-Bale areas of Oromia region have high level of mechanization use due to the highly productive land in the region as well as past big mechanization projects. The research carried out by IFPRI showed that a spatial patterns in mechanization concentration in the Arsi/Bale area, western Tigray and parts of Somali region. Farmers in these regions were interested in mechanical threshing due to the initial promotion of agricultural machienery (Johnson, 1972, cited in Hassena et al, 2000). According to IFPRI's report, the reason for this concentration of machinery in these parts of the country could be attributed to the presence of commercial farms or generally larger smallholder farms, a history of intervention, higher rural wages, flat and stone-free terrain, and time constraint for two harvests in a year (IFPRI, 2017). Nowadays, in major wheat growing areas, such as Arsi and Bale zones in Oromia region and West and East Gojam zones in Amhara region, wheat is harvested using combine harvester being operated on hire service arrangement (FAO, 2017).

Ownership of agricultural machinery is a challenge for a smallholder farmer in Ethiopia. Small farm size and seasonality have often been seen as a major limitation to the use and ownership of agricultural machineries. In most cases, the management of tractors in small-scale farming is often under capacity and uneconomical. As reported by FAO (1996), most farmers in developing countries cannot justify ownership of the tractor for exclusive use on their own farms due to small farm scale owned. Since tractors are not possible to utilize to their full capacity, smallholder farmers are forced to look for a collective use of the tractor such as private contractors, machinery cooperative, machinery ring, national machinery station and tractor hiring (Gego, 1986). Custom hiring companies of farm machinery (CHCs) are a unit comprising a set of farm machinery, implements and equipment for hiring by farmers. These companies give farm machinery on a rental basis to farmers who cannot afford to purchase high-end agricultural machinery and equipment. Due to the above mentioned reasons, farmers made decision to hire different agriultural machineries and equipment from service providers.

1.2. Statement of the Problem

Today 50 percent of the population in developing countries lives in the rural sector and this will fall to 30 percent by 2050 (Sims and Kienzle, 2016). Ethiopia has one of higher rate of urbanization (4.3 percent) as well as rapidly increasing urban centers (Demese, 2007:85). Young people are turning their back on agriculture. Farming as they most often see it

practiced (e.g. by their parents) is hard, risky, poorly remunerated and of low status, and it does not fit their image of a modern job (Asciutti E., et al., 2016). Rapid urbanization leads to increased market demand for agricultural products such as cereals, which require more labor than other crops (IFPRI, 2017). Due to increase in urbanization, agriculture is likely to continue be affected by labor shortage unless supported by mechanization technologies.

Nearly 87.1 percent of the population in Amhara region resides in rural areas. They largely engage in agriculture and agriculture related activities (Amhara Info, 2010). Agricultural production and productivity is low to feed the growing population in the region. It is argued that the traditional means and practices of farming on the one hand and socio-economic factors on the other hand contribute to this low production and productivity (Mengistu, 2000). Therefore, increasing agricultural productivity is critical to meeting the continuous rising demand for food.

Mechanization and good management can result in better timeliness in field operations and on good soils this can result in improved yields (Landers, 2000). To increase yields, mechanisation driven by higher farm-power levels is proposed by several scientists as a possible solution (Baudron et al., 2015; Sims et al., 2016; Ströh de Martínez et al., 2016). Although it has been shown that the usage of farm machinery improved labor efficiency, production input efficiency and timeliness of operations; there is still a low adoption of tractor and combine harvesting technologies in the most part of Ethiopia. The Ethiopian agricultural transformation agency (ATA) has introduced combine harvesters in the study area for harvesting and threshing and yet a sizeable number of growers are still harvesting and threshing their wheat manually and/or threshing by animal trampling (FAO, 2017).

To exploit economics of scale in the use of agricultural machinery and limitations in the financial capacity of farmers to own farm machinery, it is necessary to improve hiring arrangements to provide mechanization services to small scale farmers. Custom hiring services for agricultural machinery enable farmers to utilize the appropriate equipment for a defined period paying for the services (UNESCAP, 2017). However, hiring decisions are based on several factors whose relative importance varies among farmers.

Several factors have been outlined in few studies carried out in Ethiopia as what could be the causes of adoption of mechanization services. For instance, (Berhane G. et al., 2017) in

their study in the *Feed the Future* regions of Ethiopia. Farm size and rural wages are positively associated with the adoption of mechanization, while remoteness is negatively linked. A similar study by (Challa, 2016) in Arsi and Bale zones of Oromia region found that different factors like age, education of households, landholding, family size and technology access are the main contributors for the low level of technology utilization. Another study by Takele A. and G. Selassie, (2018) in northern Ethiopia found that being a model farmer, sex of a household, land holding, adult female labor endowment, oxen endowment and experience in use of herbicides were positively and significantly affecting farmers' willingness to use tractor hiring services.

Previous studies, mostly, paid attention to the different factors affecting the adoption of mechanization technologies with no specificity of hiring services (Takele and Gebre Selassie, 2018; Challa, 2016). Arsi and Bale areas have long experience in the use of mechanization services, whereas the study area has recent experience, hence the magnitude of the different factors and their effect on the farmers' hiring decision varies due to difference in cultural and years of experience. This study will help to compare the previous results. In addition , despite the fact that there is already information about the increase in the usage rates of farm machinery mainly in the Arsi and Bale regions of the country, very little information is available regarding the cause of low rate of usage in the norther part of the country.

Few studies tried to address willingness of farmers to use tractor hiring services. They were not exhaustive in addressing the different types of machinery services. For example, the study conducted by Takele A. and G.Selassie (2018) mainly focused on one axle tractor hiring services and doesn't cover two axle tractor and combine harvesting services. In addition, their study was mainly focusing on the willingness of farmers to use tractor hiring services, it didn't explain the factors that affect hiring decision of farmers. Examining the willingness of farmers is a good contribution. However, willingness may not by itself is enough to hire mechanization services. Farmers may be willing to adopt but may not necessarily decide to hire. There are several factors (internal and external) that can influence the hiring decision of farmers. With recent rise in demand for mechanization in the research area and the associated growth in tractor hiring services, different factors affect the hiring decision of farmers. Internal factors may include financial capabilities and operation skills of farmers. External factors, on the other hand, may include factors that farmers can have

limited or no control over them. These include the limited capabilities of service providers, government policy, land availability etc.

The availability of machinery service providers in the area is an important factor for the smallholder farmer to make hiring decision. An important potential determinant of accessibility of tractor service is the presence of tractor owners in the vicinity (Takeshima et al 2016). According to Debre Elias woreda office of agriculture, there are few service providers operating in the area for the past couple of years. These service providers have tried to deliver the required mechanization service (tractor and combine harvester), although they are constrained with some factors. In the study woreda, the number of farmers who are using the services is increasing over years. Some farmers use both services for ploughing and harvesting, and others use for either of. Based on my personal communication with farmers and local experts and preliminary survey in the woreda there are few factors identified for hiring decision for mechanization services. However, the information is not sufficient mainly for two reasons. First, the factors mentioned by farmers during personal communication were not exhaustive implying the presence of other potential factors that determine the hiring decision. Second, the quick information that was collected didn't properly follow the research procedures and the information also didn't properly assessed. This research was mainly conducted to fill the gap i.e. further investigation to determine factors affecting the hiring decision of smallholder farmers for mechanization services in the study area.

The information generated from this research would be useful and essential for stakeholders working in mechanization area by understanding various factors influencing the sustainable operation of farm mechanization service provision to smallholder farmers. Thus, this study is justified as identifying factors affecting the hiring decision of farmer towards mechanization services and will provide recommendations and some insight for both service providers and government to improve their services and implement various intervention programs.

1.3. Objectives of the Study

1.3.1. General Objective

The overall objective of the study is to identify factors that determine the hiring decision of farmers for using agricultural mechanization services in Debre Elias woreda, East Gojam zone, Amhara region.

1.3.2. Specific Objectives

1. Identify the major sources of tractor and combine harvester hiring for mechanization in the study area;
2. Identify factors that affect farmers' hiring decision of tractor mechanization services; and
3. Identify factors that affect farmers' hiring decision of combine harvester mechanization services;

1.4. Research Questions

1. What are the major sources of tractor and combine harvester hiring for mechanization in the study area?
2. What factors influence farmers' decision for using tractor mechanization services?
3. What factors influence farmers' decision for using combine harvesting mechanization services?

1.5. Significance of the Study

There is a large body of research on understanding various factors that can potentially affect the adoption of farm mechanization technologies (Takele and Gebre Selassie, 2018; Berhane G. et al., 2017; Challa, 2016). However, little discussion has been given in understanding and prioritizing factors that determine the hiring decision of farmers and how machinery service providers are working within the dynamic change of these factors.

For Ministry of Agriculture (MoA), this research could provide insights about the critical factors that determine farmers hiring decision of mechanization services for further timely action and development of appropriate interventions to address the existing challenges in accessing such services. The information generated from this research could also be useful for service providers to understand the decision-making processes of farmers and to improve their operation and service efficiency. Similarly, farmers' cooperatives and unions may use this knowledge in assisting their members to hire mechanization services and improve quality, profitability and efficiency of their farming operations. To large extent, the

recommendations of this research may help youth to engage in agriculture, if the efforts on the increased use of tractors and harvesting mechanization technologies are successful. In addition, the study could also add to the body of literature in the context to farm mechanization custom hiring business. Hence, this study will benefit for uncovering the problems and filling practical and theoretical gaps in the academic community, service providers, users and policymakers.

1.6. Scope and Limitation of the Study

The study is delimited to farmers in East Gojam zone of Debre Elias woreda. Farmers who never used and who hired services for mechanization were considered in the study. The study basically focused on two mechanization services of tractor ploughing and combine harvester operation. Some of the factors for hiring decision may be context specific, which can't be directly translated into different contexts.

The findings of this research are based on the data available at the time. While useful, the results of the survey must be viewed with caution because of possible response bias. Further studies might be needed to enrich and investigate more the decision-making behavior of farmers and to do a more in-depth study in a wider geographical scale including for additional mechanization services.

CHAPTER TWO: LITERATURE REVIEW

In this chapter, the role of farm mechanization in agriculture, concepts of custom hiring and empirical studies on various factors impacting machinery hiring decision of farmers are discussed briefly.

2.1. Theoretical Literature Review

2.1.1. The Role of Mechanization in Agriculture

Mechanization in the agricultural sector has been defined in several ways. FAO defines mechanization as "the application of tools, implements and machinery in order to achieve agricultural production" (Clarke, 1997). To mechanize means to use machines to accomplish tasks or operations. A machine may be as simple as a wedge or an inclined plane, or as complex as an airplane. Agricultural mechanization, therefore, is the use of any machine to accomplish a task or operation involved in agricultural production (ASAE, 1999). The role of mechanization in agriculture is to reduce labor peaks through improving the quality of work and assist carrying out work on schedule (Gego, 1986). Mechanization is a key component of the technology that allows agricultural production to be intensified. When there is an increasing demand for food, more land must be brought under cultivation, or to intensively cultivate the existing land, requires more labor use per unit of land, mechanization will be adopted. A typical farm family that is reliant solely on human power can only cultivate in the region of 1.5 ha per year. This will rise to 4 ha if draft-animal technology (DAT) is available, and to over 8 ha if tractor power can be accessed (FAO, 2006). Mechanization can assist to increase production and profitability, improve the use of inputs, reduce the cost of production and assist in employment opportunities.

According to ASAE, three broad levels of agricultural mechanization technology are classified as hand-tool technology (HTT), draft-animal technology (DAT) and mechanical-power or engine-power technology (EPT). The level of mechanization on a farm depends on many factors but a major determinant must be the question of return on investment (Landers, 2000). Animal power accounts for about 20 percent of agricultural mechanization in developing countries; human power accounts for 70 percent, mechanical power 10 percent (ASAE, 1999).

Agriculture is one of the bases of the national economy of Ethiopia because it is the main source that supplies the population with food and raw materials for the processing industry.

Agricultural production is predominantly relying on draught animal power. Animal traction has been an integral part of most agricultural systems in Ethiopia for thousands of years. There is evidence that cattle were first used for ploughing in the latter part of the third millennium BC (Goe and Astatke, 1989, cited by FAO). All cultivation in the highlands is carried out by oxen pulling the traditional plough called 'maresha'. Farmers plow their land from two to six times per planting depending on the crop that is to be planted. The depth of the first ploughing ranges from 5 to 8cm, while the last pass may be up to 20cm deep. The time required to prepare the land also varies from 100 hours per hectare to 150hours per hectare for light soils and deep vertisols, respectively (Astatke and Matthews, 1982). Furthermore, this ploughing practice is considered as a hard work for the farmer who must walk long distances in the already ploughed field. A typical farmer uses a pair of oxen for around 450 hours a year for cultivation and threshing (Gebregziabher et al., 2006). Ploughing one hectare of land in the Ethiopian highlands with animal traction takes up to 50h per pass (Aune et al., 2001) and labor is important for operations such as hand-weeding (Amare, 2014; Workayehu and Wortmann, 2011).

A typical small family farm in Ethiopia consists of 5 persons and is predominantly male headed, only 21 percent of the farms are feminized. The household head generally has only primary level education, on average less than 2 years. About 67 percent of the small family farms in Ethiopia live below the national poverty line (FAO, 2018). One of the principal causes of poverty among small scale farmers is the lack of farm power (labor saving tools and equipment, and mechanized power) and importantly access to it. Lack of availability and access to farm power by smallholder farmers is a key factor that leads to a decline in production and consequently farm output. If operation is performed with delay, value of crop may decline due to changes in quantity and/or quality (ASABE, 2006a). The economic consequences of performing a field operation at non-optimal time are called timeliness costs. Timeliness of farming operations can also have a critical effect on crop yields. Delays in planting after the optimal date can amount to yield penalties of up to one percent per day of delay (Ronald, 2008). A delay of two weeks causes a 50 percent difference in crop yield (Gryseels, 1988). Srivastava et al. (2006) mention increasing machine capacity as one way to decrease timeliness costs, as larger machines with greater capacity can accomplish more timely work.

(Khan,1971, cited by H.P.F. Curfs,1976) argues that to keep the land in near-continuous production, mechanized production methods are of urgent necessity to the tropical farmer, especially since the income of farmers who have adopted new, high yielding varieties and cultural practices have usually risen sharply and this has provided an impetus for mechanized cultivation. Wheat production in Ethiopia can become attractive for mechanization and the increase in yields must be substantial to justify the cost of mechanical cultivation. Production increases in the past were mainly due to the extension of cultivated area and only to a lesser extent due to higher yields (Friedrich and Kassam, 2011; Taffesse, Dorosh, and Asrat, 2011). While productivity has always been a concern, policymakers, donors and private actors across Africa have, in recent years, rediscovered agricultural mechanization as a potential way to raise both labor and land productivity and started major mechanization efforts (Daum and Birner, 2017; Diao et al., 2016).

The significant roles of mechanization in agriculture to farmers, whether as the users of machinery or as the provider of machinery services, can be summarized as follows: 1) increasing farm labor productivity and reducing drudgery, 2) increasing agricultural production and productivity, and 3) increasing returns to farmers by reducing costs of production (Gego, et al., 1986). With these essential roles of mechanization in agriculture, many developing countries continue to implement mechanization in their policy. Pingali et al. (1987) argued that field tasks, particularly land preparation, are usually the most power intensive. Therefore, the most power-intensive operations are usually the first to be mechanized. It has frequently been argued that agricultural mechanization by reducing the drudgery of agricultural labor can make agriculture more attractive, particularly to the younger, better educated and more enterprising members of rural society and, thereby, reduce the rural-urban drift (FAO, 1985).

Agricultural tractors form the pivot of agricultural mechanization. Multi-functionality would ensure that the tractor does not stay idle for much of the year. Farming activities such as ploughing, harrowing, ridging, planting, weeding, fertilizer/pesticide application, harvesting water pumping, and transportation of farm produce can be carried out. As stated by FAO (1985), institutional support is needed to create a sustainable environment for introducing and sustaining the multi-farm use of machinery, provided by farm machinery owners, including the machinery hire providers. Institutional support arrangements will vary across developing countries and may be grouped according to the type of activity and service

provided (Houmy et al., 2013). In general, the institutional supports are financial/credit services, extension services, training for machinery operators, repair and maintenance facilities (including spare parts), and infrastructure (FAO, 1985; Houmy et al., 2013; IRRI, 1986). Financial assistance in the form of credit or subsidies is arguably and effective means to support agricultural mechanization in developing countries (FAO, 1985).

Whether farmers can afford to use external inputs like mechanization also depends on the size of the farm. The relationships between farm size, income, and level of agricultural mechanization are important in most developing countries, though there is no easily calculated level of farm size which is an indication of poverty (FAO, 1985). The policy of a country on land tenure is an important determinant of which level of mechanization is appropriate and on the type of mechanization inputs that are appropriate within each level (FAO, 1985). It is argued that the current land-tenure system of Ethiopia discourages farmers from investing in the farms. Land in Ethiopia is state-owned making it impossible to sell land or to use it as collateral for loans. Thus land-transfers to more productive farmers is a challenge. According to Tafesse Olika, land right has been and remain a central problem in the development of the agriculture sector (Tafesse Olika, 2006).

The farm holding system also affects mechanization (i.e. whether the farm is operated by the owner, by a tenant, or by a sharecropper). In the first instance, farmers who do not own their land are often unable to secure credit to purchase mechanization inputs because land may be the only acceptable collateral for loans. In the second instance, these farmers often do not have security of tenure and they are reluctant to invest in higher levels of mechanization in the face of the uncertainty as to whether they can continue their tenancy or share cropping arrangements over a long enough period to amortize the investment (FAO, 1985).

2.1.2. Custom Hire

Custom hire service is a farm machinery business that is managed by either a group or an individual to provide service for performing farm operations. Custom hiring services for agricultural machinery enable farmers to utilize the appropriate equipment for a defined period of time, only paying for the services. The custom hiring system play a pivotal role in introducing high technology agricultural machinery to even small farmers with the objective to boost crop production, improve quality, timeliness and efficiency of agriculture

operations. According to (Landers, 2000), hiring offers greater flexibility, the ability to match machinery to annual requirements-very important if the area changes or the cropping pattern is affected by the weather or market conditions and a fully overhauled machine (ready to work and supported by a comprehensive system which includes all repairs, maintenance, insurance, guarantees, and operator instruction/assistance).

The most popular services that hire services provide as a business are devoted to farm production and concern land preparation, planting and spraying, FAO (2012). Hire services offer also other services along the agri-food value chain such as, for example, post-harvest services, the most popular being threshing and shelling, processing, as well as marketing services such as transport, packing and street hawking for selling farm produce (FAO, 2012).

Small holder farmers of cereal crops in Ethiopia do not have enough capital to buy agricultural machinery. In addition, the small size of the field does not allow the use of these machines with economic efficiency where the cost of operation of the machines is high. Due to that, hiring mechanization services has become an acceptable option. In many developing countries, ownership of farm machinery is very limited because of the small sized farms owned by the majority of farmers (Gego et al., 1986). Additionally, the ownership of machinery for many farmers in developing countries is mainly determined by its economic viability (Singh and Kingra, et al., 2013). Furthermore, it required capital investment, and depends on the availability of finance of farmers (IRRI, 1986). This fact often leads to the collective use of farm machinery by farmers or individuals in groups or organizational form (Gego, et al., 1986). In general, these organizational forms are classified into public and private sector categories, but some forms are organized by both parties (FAO, 1985).

In developing countries, the following forms of farm machinery ownership exist: 1) public hire service, 2) private hire service, 3) private owner-user with hire service for excess capacity, 4) exclusive private owner-user, 5) cooperative ownership, and 6) informal joint ownership (IRRI, 1986).

Agricultural machinery services are popular in developing countries, because the majority of farmers are smallholder farmers who are unable to expand and intensify the production of food and cash crops due to the lack of availability or access to farm mechanization (Sims et al., 2011). Through machinery hiring, small-scale farmers can utilize farm machinery

without owning it. According to Sims et al. (2011) hire services (rental, custom, or leasing services) in agriculture are an activity of machinery service provider in delivering services to farmers, which may include land preparation, planting, spraying, threshing or transportation. Machinery service providers can help reduce labor and tractor peaks, machinery costs per hectare and often offer a faster service. Disadvantages may include failure to arrive on time and an inferior service (Landers, 2000). Farmers in Ethiopia hire tractors mostly for the first plough (typically there are about 3 ploughing/disking/harrowing operation). This is because the first operation is the most difficult and heavy for oxen while a big tractor can do deeper ploughing.

Several efforts to introduce tractors to Ethiopia have been made in the past. State-owned hiring schemes that were running between 1970 and 1990 collapsed due to the financial burden (International Maize and Wheat Improvement Center, 2014). A similar development took place in many SSA countries, hence there has often been a call to focus efforts on private sector involvement (Baudron et al., 2015; Duerr et al., 2016). As reported by CIMMYT (2014b) hire services from the public sector, via cooperatives, mainly focus on production and harvest services, while the private sector provides for post-harvest services and transport. In order to create a facilitation policy to foster mechanization in developing countries, many scholars suggest that the role of the public sector should be adjusted to give the opportunity for the private sector, to develop their market in the machine hire business (Clarke, 2000; Diao et al., 2014; Houssou et al., 2013; kienzle et al., 2013; Pingali, 2007). For instance, the public sector should be able to promote the demand for farm machinery and the provision of spare parts. The public sector should facilitate the private sector in acquiring and maintaining farm machinery through the reduction of transaction costs, such as changing the importation policy as evidenced Bangladesh and Ghana (Biggs et al., 2011; Diao et al., 2014).

Low purchasing power means low demand, which provides for low investments for example in purchasing machinery, which in turn undermines the manufacturing and spare parts segments of the supply chain as well as support services for its appropriate functioning, such as for example maintenance and fuel services (FAO, 2016).

Machinery hire services tend to have seasonal demands, as a result of the seasonality of agriculture. Furthermore; the seasonal work of machinery is influenced by various factors,

such as the total working days during crop season and the number of available machines. Field conditions also influenced the work of machinery, these include field size and shape, weed population, and distance from the machine center to the farm (Paman et al., 2014, 2016). Additionally, the transaction cost and service charges set by machinery service providers influence the demand for machinery hire services. It is also common for service providers to migrate across different agro-ecological conditions as a provision of extending services to increase the demand. According to Bigot and Binswanger (1987), the migration of machinery service vendors is one of the characteristics of successful tractor-rental operations because, through migration of tractors across agro-climatic zones, it can increase the utilization of the machines.

2.1.3. Determinants for Using Mechanization Technologies

Availability and Cost of Keeping Oxen

Farmers usually maintain cows to produce replacement oxen. Although oxen are currently the main source of power for cultivation, they are used for less than 113 days in a year, however, the oxen have to be fed for the remaining 252 days (Alemu G. et al., 2003). Due to increasing population and livestock pressure on the land, farmers in developing countries may not be able to continue maintaining draft oxen specifically for work purposes (Zerbini et al., 2003). In the Ethiopian highlands about 8% of farmers have three or more oxen, 29 percent have two, 34 percent have one and about 29 percent have no oxen (Gryseels, 1988). Farmers with one or no oxen are the ones who normally have problems in completing their farm operation on time. These farmers have to rent out, crop-share, exchange or loan out their land in order to finish cultivation on time (Alemu G. et al, 2003). Hence more than 60% of the farmers have to rent or borrow one or two animals for cultivation. Oxen rental cost for tillage is high and unaffordable to most farmers in Ethiopia (Aune et al., 2001) despite the low access to oxen particularly during peak time of planting. (Jim Ellis-Jones, et al., 2013) reported that, many farmers indicate they do not have enough draft animals and inadequate equipment with farmers resorting to sharing or borrowing oxen. This often results in late land preparation, late planting and subsequent yield losses.

Lack of farm oxen force farmers to engage in distress sales of their food crops simply to buy farm oxen (Gebresilassie A., and Bekele T., 2010). According to them, this emergency sales often disrupted the farmer's intended usage and could lead to shortages. Another possible arrangement, traditionally called 'mekenajo', involves the exchange of farm oxen

between farmers who collectively own only one animal. Access to oxen can be seen to been more important than land size in the Ethiopian context; because without the oxen, the land cannot be cultivated (Takele and G. Selassie, 2017).

A severe lack of grazing and fodder resources is leading to a decline in most livestock numbers. The seasonal shortage of livestock feed is acute in the highlands. Grazing on communal lands supplemented with straw, crop residues and stubble grazing constitutes the main source of feed. Feed shortages are further aggravated as grazing lands are converted to production. The relatively short working life in relation to the long training period of draught oxen and high feeding costs if pastureland is not available, make an oxen a very significant and costly investment for the average peasant farmer (Hans, 1994).

To sustain a pair of oxen a considerable amount of feed resources are required and due to grazing land scarcity oxen prices have almost doubled between 2001 and 2016 threatening the livelihoods of smallholders (Berhane et al., 2017).

Cost of Hiring Oxen

Traditional soil preparation in Ethiopia requires three elements: the operator, a pair of oxen and the tillage implement (Aune et al., 2001). The tillage frequency depends on different factors such as crop and soil type and weed infestation. According to Gebregziabher et al. (2006) legumes only need one to two passes whereas cereals need three to four passes and long-term fallows up to seven. In a study in southern Ethiopia 83 % of women-headed households and 67 percent of male-headed households faced a shortage of oxen to undertake agricultural activities. There is high rental cost for oxen in Ethiopia (Aune et al., 2001) and conventialal tillage is expensive to farmers without oxen (Tulema B. et al., 2008).

Farmers with no oxen have to make use of different exchange mechanisms. (Klappoth, 2017) indicated that oxen owners charge high amounts of the harvest for their service (up to 75 percent). It is clear that such an exchange mechanism is a heavy burden for those farmers that have to make use of them. In general, it is young and female farmers who are the ones with lowest land holdings who have to use the exchange mechanisms. Small farmers who rely on oxen of others for land preparation cannot plough at the right time (due to short preparation time at the onset of the rainy season) and pay between one quarter and

half of their output of cereals and pulses for hiring a pair of oxen (Takele and G.Selassie, 2017).

Labor Shortage

Labour availability for agricultural operations has changed dramatically, with other sectors competing for paid labour. Many actors now see new economic and socio-economic conditions as a chance to mechanize the Ethiopian smallholder agriculture. Peak season labor scarcity problems are aggravated in areas where two or more crops are grown on the same field each year. The increasing scarcity of the labour force in rural areas due to migration of mainly young men to urban areas constitutes a great challenge to poorer farmers, often women-headed households (Baudron et al., 2015; Sims, Hilmi, and Kienzle, 2016; Ströh de Martínez et al., 2016). Schmidt and Kedir (2009) estimate that, based on an agglomeration index approach and using the last three national censuses (1984, 1994, 2007), urbanization rates increased from 3.7 to 14 percent over the period studied, almost quadrupling the urban share of the national population (FDRE, 2008).Women are also forced to take on a male's agricultural workload when their husbands or older sons migrate to cities to look for work. The migration leads to a continuous rise in women-headed households.

The chain explanation highlights the importance of low farm productivity and low profitability-associated with the limited use of modern technology and poorly functioning rural institution-in explaining why young people turn away from agriculture (Asciutti et al., 2016). Tractor use reduces labor use per hectare for land preparation but leads to an increase in area cultivated by tractor farms, where uncultivated or fallow land is available (Pingali, Bigot and Binswanger, 1987).

Land Size and Land Tenure System

The smaller the farm size of the farm plots, the less frequently the farmers apply improved technologies (Workeneh Nigatu, 2006). Smaller land sizes are less suitable for tractor hiring for reasons of: the cost of hiring and the effort involved to organize hiring, the availability of manual labor and oxen to do a similar job, fragmented land parcels, and the difficulty of accessibility and turning space. Private machinery owners or the union were only interested providing tractor hire services for ploughing when there is a sufficiently large amount of land to be ploughed at one time (Bymolt and Zaal, 2015). Workeneh Nigatu argues

(Workeneh Nigatu, 2006) that tenure security and the size of farmlands are two most important determinants of farmers' application of improved technology. Farmers should be able to buy and sell land and enjoy full entitlement of their holdings as this give them to have security of tenure and the possibility of using their farms as collateral for loans (Merma, 2008).

Availability of Farm Machinery Hiring

Availability of machinery service provider in the nearby area of smallholder farmers is among the first factors that are contributing for making hiring decision. Hiring of mechanization increases when there are near machinery hiring stations. Proximity of machinery hiring service provider near farmers is an important potential determinant for accessibility of tractor service (Takeshima et al., 2016). The knowledge that mechanization service exist is the very first step towards adoption of agricultural technology. Lack of or low level of adoption of mechanization is often attributed to supply side constraint. To increase the number of machinery service providers, demand need to grow. In Africa, markets for mechanization hire services usually have very little demand due to the lack of awareness among smallholders of the need for mechanized services (FAO, 2016).

Extension and Promotion

Access to extension is essential in promoting modern agricultural production technologies. Through extension, farmers can acquire information about new technologies. Access to agricultural extension services have made mechanization available for small-scale farmers in the country (Sims et al., 2011). Available information about the new technology influences its adoption. It enables farmers to know much about its existence as well as the effective use of technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Technology adoption among farmers is higher when extension services are made available. If farmers are to adopt new agricultural technology, they must be confident that the technology in question will work on their farms. This confidence can be provided through effective communication system. Demonstration farms are dissemination instruments and should be involved in the training of young farmers who need to become acquainted with new and advanced technologies (ASAE, 1999).

Road Access

One of the factors pointed out for minimal availability is existence of poor infrastructure that would increase delivery costs of machinery and services. Rural roads are frequently in a state of poor repair, which adds to distribution costs. About road infrastructure, it is argued that the poor condition of road infrastructure influences time required and fuel consumption to travel to remote areas to provide farm services (Sims and Kienzle, 2009). Good condition of rural roads allows easy movement of equipment for delivering services and easy access to repair and maintenance facilities. In Ethiopia, an average distance of 44 km to the closest road isolates many farmers from more lucrative markets (FAO, 2017).

Furthermore, registration can be an issue if the owner wishes to transport a tractor across district lines to deliver hire services (Bymolt and Zaal, 2015). Moreover, large distances between smallholders wishing to hire services puts off machinery service providers due to the transaction and fuel cost.

Access to Credit

The low purchasing power of small-scale farmers in agri-food value chains has also undermined the development of hire services. Access to credit can ease farmers' liquidity constraints, alleviate households' risk-bearing conditions, and thus increase the adoption chances of a new technology (Zuhui Huang and Taonarufaro Tinaye Pemberai Karimanzira, 2018). In many cases, the cash that a farmer receives as credit for adopting a new agricultural technology is not used for its intended purposes. Research in Iran and Niger reported that a farmer receiving credit for adopting a new agricultural technology can often misuse it for other purposes (school fees, house repair, etc.) creating a high reimbursement risk (Sunny et al., 2018). Hence, supply of credit need to be combined with special advisory services to ensure that credit is used only for its intended purposes.

Cost of Hiring

The cost of hiring mechanization service should be affordable by small scale farmers. In Ethiopia, ploughing cost vary depending on availability, soil type, soil condition and distance of the farm from major towns. Average hiring costs for ploughing service was 1,600 ETB per hectare in most parts, and this could reach to 2000-2500 ETB/hectare in some areas (MoA, 2020). Smallholder farmers are, almost by definition, resource poor and often have difficulty investing in physical assets in general and in agricultural machinery in particular

(FAO, 2016). Small-scale farmers commonly have low productive output per hectare due to lack of access to inputs resulting in getting low prices for their produce, consequently lack financial resources to buy services from a hire service. To access mechanization services, some farmers are forced to pay in kind.

Better Yield

Farm mechanization increases the cropping intensity, resulting more plants per hectare which ultimately increases the yield per hectare. Using traditional methods of harvesting is prone to losses that include consumption by livestock during threshing, loss by wind when winnowing and during transporting from field to the farm. Better yield as a result of using mechanization is attributed to reductions in yield losses during and after harvesting (IFPRI, 2017). Timeliness factors are also responsible for quantity and quality losses. The majority of timeliness costs were caused by delays in the start of sowing or harvesting (Gunnarsson, 2008). It is essential that sufficient technical skills, sound knowledge, and experience of agricultural machinery operation are required for operators to be able to perform machinery services. The agriculture sector is projected to become economically sustainable because of the rapid expansion of urban centres and the associated demand for agricultural products, in addition to the increases in international food commodity prices (FAO, 2016).

Farm and Off-Farm Income

Agriculture is by far the main occupation for Ethiopian smallholdings, with on-farm income accounting for 79 percent of income and crop production being the most frequent form (62 percent) (FAO, 2018). Farmers who owns larger farms are with better income and are most likely to adopt technologies. Off farm income has also been reported to have positive impact on technology adoption. This is because off-farm income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries (Reardon, Stamoulis, and Pingali, 2007). Off-farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis and Freeman, 2004). According to (Diiro, 2009) off- farm income is expected to provide farmers alternative source of liquid capital for purchasing productivity enhancing inputs such as improved seed and fertilizers.

Brokers

There are two types of hiring mechanisms which are as follows: hiring directly from service operators and hiring through a broker. Hiring directly form machinery service provider takes the operator gathering farmers who require mechanization services in the beginning of farming and operators spread the news by word-of-mouth. Farmers contact the service provider directly to secure their place on the queue. When hiring is arranged through brokers, there is a negotiation between farmers and brokers. Brokers commonly assess quantities of harvest and the time when areas are ready to be harvested and then coordinate with mechanized service Providers (IFPRI, 2017). The brokers can play a role of gathering the fields and managing the queue for the machinery service providers.

Risk and Uncertainties

Most of the decisions in the farm businesses are made under uncertainty. Farming has always been considered a high-risk business subject to many uncertainties. Factors causing production risk are, for example, weather, diseases of animals and crops, and pests (Laitila Salo, 2001).

Land Fragmentation and Topography

Smallholder agriculture accounts for 85 percent of Ethiopia's total agricultural output (Fantu et al., 2015), and 60 percent of farming households operate on less than one hectare of land (CSA, 2015). Many of these farms are split into numerous spatially dispersed parcels. Land fragmentation and the cultivation of discontinuous fields is said to hinder the expansion of improved mechanical technologies and the efficient use of irrigation (Demetriou, 2014). In areas where that are too far from the main road and in areas with more rugged terrain, hiring a mechanization service is discouraged as the cost of movement between farms is high. The adoption of hired tractors was discouraged in areas with more rugged terrain and higher elevations because greater ruggedness may raise the costs of tractor movement between farms (Takeshima et al., 2016).

2.2. Empirical Literature Review

There are empirical studies on factors determining the adoption of farm mechanization technologies. Some of these factors are shown to be significant in influencing the operation of machinery service providers. The findings of (Takele and G.Selassie, 2017) in northwestern Ethiopia showed that shortage of oxen (52 percent) and labor (43.3 percent)

were found to be challenges related to ploughing practice. They used binary logistic regression to analyze the willing of farmers to use tractor hiring services and the result showed that being a model farmer, female headed household, adult female labor endowment, land holding, oxen endowment, proportion of heavy soil, and experience in use of herbicides positively affect farmers willingness to use tractor hire services. However, age of household head was negatively affecting the willingness to try the tractor hiring services.

John K. M. Kuwornu et al (2017), analyzed access and intensity of mechanization by rice farmers in southern Ghana. They used descriptive statistics and double hurdle model to estimate the determinants of access to mechanization. The empirical results of tier one of the double hurdle model showed that size of land, access to credit, availability of farm machinery, expenditure on labour, agrochemical expenditure, the square of age, and gender positively influenced access to mechanization. Seed expenditure, age and district locations negatively influenced access to mechanization. The empirical results of the tier two of the double hurdle model revealed that distance from farm to nearest mechanization center, rice income, non-farm income and experience were significant variables that positively influenced intensity of mechanization. Land ownership and household size negatively influenced intensity of mechanization.

Challa (2016), in his study assessed factors that determine the adoption of mechanization technology in Arsi, West Arsi and East Shoa. The result of binary logistic regression revealed that household age and distance from main market had negative impacts on technology adoption while family size, landholding and educational background of the household head had positive impact on technology adoption. And his reasearch revealed that the result for community participation had unexpected negative sign, which was supposed to favour the adoption of mechanization technology.

Berhane G. et al (2016) conducted a survey in five regions of Ethiopia to study determinants of agricultural mechanization in Ethiopia. They analyzed the uptake of different forms of mechanization using linear regression model. The result showed that household size, gender, and the age of the head are not important determinants of mechanization. In contrast, households with educated heads are more likely to use agricultural machines. The results also showed that farm size and rural wages are positively associated with the adoption of mechanization, while remoteness is negatively linked. The findings of their research

focussed mainly on the association of factors to adopt mechanization technologies using a non representative sample of the regions.

Ayandiji A and Olofinsao O.T. (2015) studied factors affecting the adoption of farm mechanization by cassava farmers in Ondo state, Nigeria. They analyzed the data using descriptive and inferential statistics. The result showed that access to extension workers and access to farm machines had a positive relationship with adoption. They also indicated that access to credit by farmers increases the adoption attitude to mechanization.

Julius A. (2014) used a decriptive statistics to analyze the data to identify factors limiting small-scale farmers' access and use of tractors for farm mechanization in Abuja, Nigeria. The result showed that high cost of tractor hiring services (64.09 percent) and inadequate sources of hiring points (19.29 percent) to be the major limiting factors. In the study, tractors are mainly used by farmers for land tillage and transportation.

The research carried out by Zaal F. and Bymolt R. (2014) in three countries (Tanzania, Kenya and Ethiopia) to assess the smallholder maize farming system and factors that shape the articulation of demand for and adoption of mechanization used a survey to gather information in Shashemene and Arsi area. They used descriptive statistics to analyze the main reasons pointed out by farmers for considering hiring a tractor. The result showed that factors such as tractors being faster (82 percent), assisting in better yields(83 percent), and increasing the ability to cultivate more land (64 percent), saving household labour (53 percent), being more reliable(37 percent), the perception that tractor hiring was cheaper than other options (21 percent) and that it can save household labour (37 percent) were considered as main reasons. They also indicated that of the whole farmers in their sample, respondents perceived tractor hire to be slightly more expensive. Reasons given for not hiring a tractor were also analyised and factors such as availability (44 percent), cost (21 percent) and distance to access (40 percent) were identified as major reasons. They also conducted a regression analysis to show the factors most influencing hiring behaviour. Accordingly, the result showed that land size under maize was positively correlated with tractor hiring behaviour. Similarly, the result showed that better-off smallholders were more likely to hire tractors. Distance to access a tractor was described in focus groups as a factor constraining tractor hiring, however the regression analysis did not reveal it as a significant

contributor, the researchers assumed that it is possibly because everyone had to travel a more or less equal distance to hire a tractor.

Hassena et al (2000), in their study on wheat harvesting and threshing technologies in Arsi Region used a sample of 160 farmers from two puposisvely selected districts of Asasa and Etheya. They applied logit analysis and the result showed that proximity to a hiring station, topography (accessibility), eduction level, and wheat area significantly affected farmers' decision to adopt combine harvesting.

The literature review above prevails that there is limited work in the area of decision making behavior of farmers towards mechanization services. Early research focused heavily on adoption of mechanization technologies, not specific to tractor and combine harvester hiring. Many of these studies have used similar approach and used descriptive statatistics and logistic regression to analyize the data, indicating wider application and the appropriateness of the model. While these studies have attempted to address the the main factors, some of the results reveal similar conclusions. Common to all is that land holding and education status seemed to have a positive effect in technology adoption while age and distance have negative influence. Although Challa (2016) found that family size and age have determinatal effect in technology adoption, Berhane G. et al (2016) in their study found that they are not important. This variablility in the effect of factors in making significant contribuition and the conflictng results suggest for further study to examine population more closely in a speciallized survey.

The making of hiring decision depends on the type of technology offered to the farmer. Most of the researches were broad on mechanization technology adoption, not on a specific technology. The research of Takel and G.Selassie (2018) was based on willingness of farmers' to use a one axle tractor that limits its validity to only a small group and for a specific tractor. Past studies were done in different regions with different socio economic characterstics. The type and degree of influence of each identified variable could vary among differnt cultures and from area to area. Hence, to compare the results of past studies and exploring additional variables, it is suggested to study and examine the factors influencing the hiring decision of farmers' on such specific mechanization technology.

2.3. Conceptual Framework

A conceptual framework was developed to provide a basis for the analysis of variables which are assumed logically to have some type of relationship with the decision-making behavior of the individual farmer to hire mechanization services. The conceptual framework is drawn based on studies that is presented in the literature review. Various factors are assumed to determine the hiring decision of farmers for mechanization services. The research focused on four areas as shown in the conceptual model, namely; the personal factors, resource factors, perception/social factors and time factors.

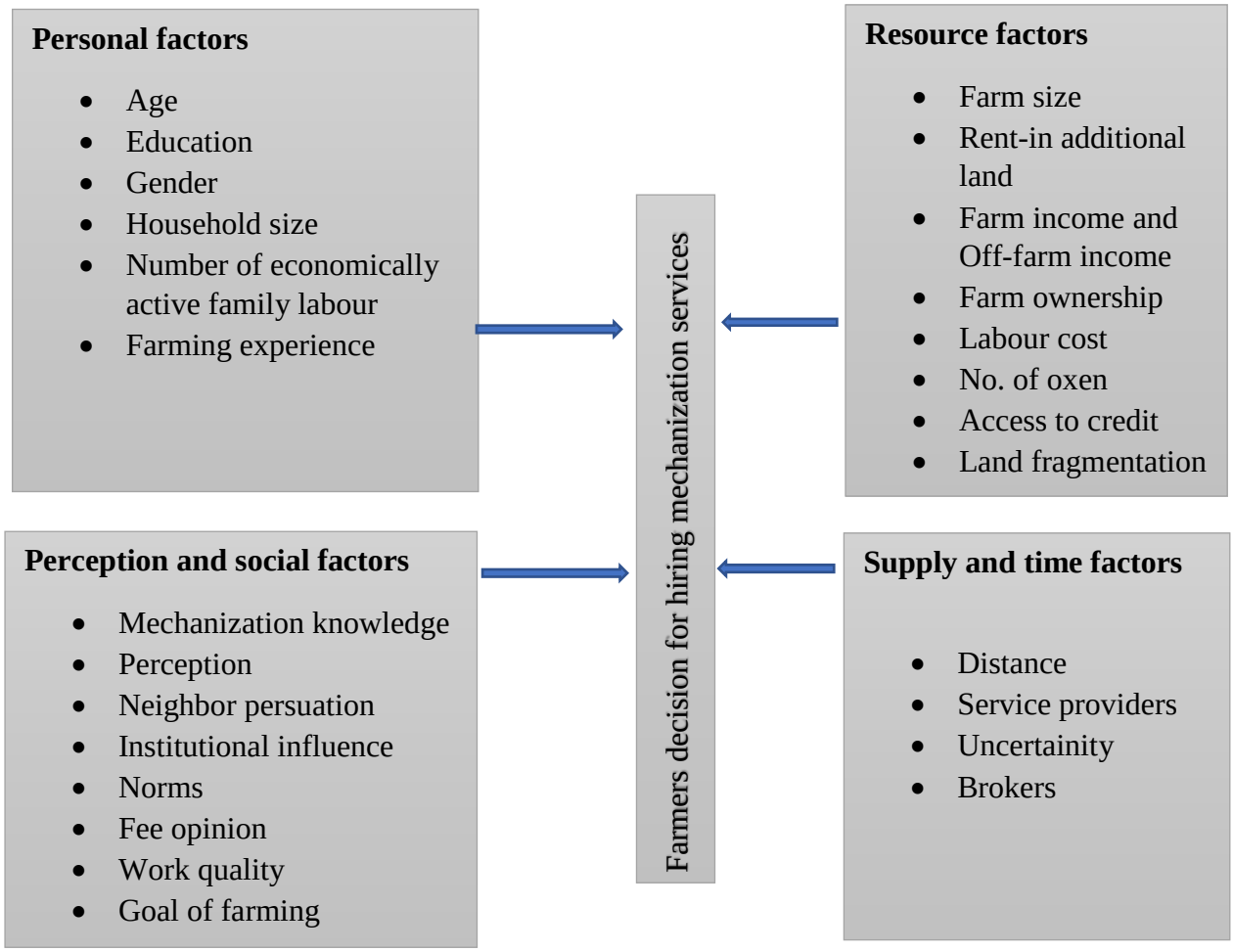


Figure 1 Conceptual Model

The four categories of factors affect the decision-making process of farmers' towards hiring mechanization services. This will then lead to whether they would hire or not.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of the Study Area

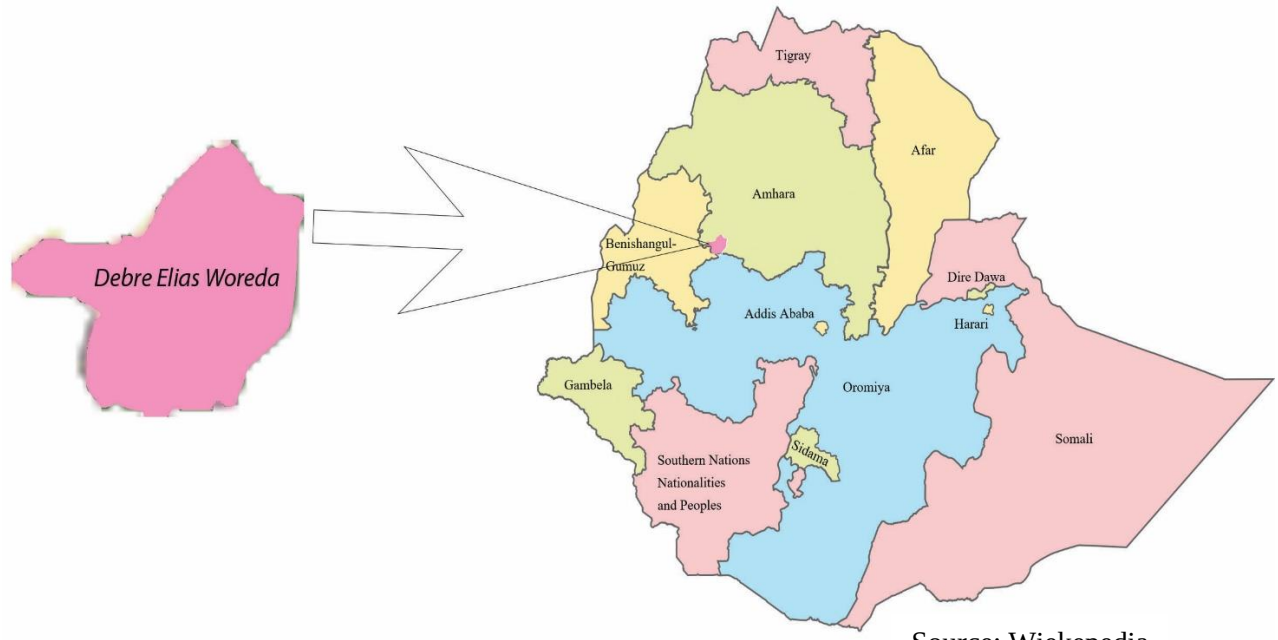
The research area is in Amhara region East Gojam administrative zone, Debre Elias Woreda. It is divided into 16 kebeles: Abashim, Yemezegn, Gibtsawit, Yedenbegn, Yegidad, Gifinama, Degolema, Yeqegat, Tijja Goter, Guay, Wamet, Chago, Genet, Dejiba, Elias Zuria and Yeguarat. Debre Elias is bordered on the south and west by the Abay river which separates it from the Oromia region, on the northwest by the West Gojjam Zone, on the north by Machakel woreda, and on the east by Gozamen woreda. The Woreda is located 42 km away from northwest of Debre Markos city.

The mean annual temperature of the woreda ranges from 18-27^{o}C and receives annual rainfall of 1150mm with an altitude ranges from 800 to 2200 m above sea level (Achenefe and Admas, 2012). The red soil is the dominant soil type and it is moderately fertile. About 99 percent of the woreda is Woyna Dega and the rest 1percent is Kolla. The area mainly consists of plain (85 percent) and the rest 15 percent is undulating topography. The area is moderately dense population that ranges from 100 to 120 people per km^2 (Debre Elias Woreda Agriculture and Rural Development Office report, 2012). Based on the 2007 national census conducted by Central Statistical Agency of Ethiopia (CSA), Debre Elias woreda had a total population of 82,150, of whom 41,109 were men and 41,041 women; and 7,928 (9.65 percent) were urban inhabitants. With an annual growth rate of 2.6 percent, the total population is estimated at 113,250 by the year 2020. Most of the inhabitants (98.94 percent) practiced Ethiopian Orthodox Tewahido Christianity while 1.01percent of the populations were Muslim.

The average farm size in East Gojjam Zone is 1.3hectares (SIDA, 2017). According to Debre Markos Information Communication, in East Gojam zone, a total of 651,822 ha area of land was planted with different crops in the production year 2019/20. Of which, 143,962 ha area was covered with wheat production. Small scale mixed agriculture is the dominant source of livelihood to the local people. Regarding Debre Elias woreda, the total area of land is estimated to be 94,000 ha. The most important crops grown in the woreda are wheat, tef, maize, fababean, barely, noug and linseed. In the year 2019/20, a total of 42,725 ha of land was covered by different crops; of which 22,000ha was covered by wheat (Debre

Markos Information Communication Office, 2020). The total volume of wheat produced in the woreda is 88,736.4 tons per year with an average wheat yield of 4.7 ton/ha. Post-harvest loss of wheat is also prevalent in the area which was estimated about 15.2 percent (FAO, 2019).

For the present study, Debre Elias woreda was purposively selected. In the woreda agricultural produce is diverse and agricultural products are the primary sources of income for the farming community. The woreda is known for sharing large volume of wheat production. Debre Elias woreda is one of the potential woredas in East Gojjam as well as in Amhara region for wheat production. It is known as one of the wheat belt areas of the region as well as the country in large. The farmers have been employing modern mechanization to maximize crop production and productivity. In addition, the moderately flat topography makes the woreda convenient for mechanization. There are growing number of farm mechanization service providers operating in the area which indicates an increased usage of tractors and combine harvesters in land preparation and harvesting operations, respectively. In the year 2018/19, for example, about 321ha of farmland was ploughed by tractor and 10,434ha of wheat was harvested using combine harvester (Debre Elias Woreda Agriculture Office, 2019).



Source: Wiekepedia

Figure 2 Study Area

3.2. Research Design

A cross-sectional survey design was employed for this study. This design involved collection and analysis of data from a target group that is representative of the entire population. Summary of the findings from the selected group could represent the entire farming community of the woreda. In cross-sectional survey, data were collected from target groups once and the information was analyzed using appropriate statistical techniques and results presented.

3.3. Types and Sources of Data

The type of data that was used in this study was primary data as well as secondary data. Primary data was gathered from farmers in Debre Elias woreda in the month of August 2020. Secondary data were gathered from publications of government, non-governmental sources and websites.

3.4. Methods of Data Collection

Data was gathered through interviews, focus group discussions, and document analysis. A structured questionnaire which consisted of various information in order to obtain the relevant information from interviewed households. Moreover, the questionnaire was designed to collect both qualitative and quantitative data. To collect the information from the respondents, three enumerators were selected based on their educational qualification (diploma and above), recommendation from woreda office of agriculture and their experience in working with farming community in the area. Enumerators have been briefed the objective of the study, the reason why information need to be collected from individual respondents and the procedure they should follow regarding anonymity and confidentiality of the interview. Moreover, enumerators were also briefed to take maximum care in data collection and to approach interviewees in a very respectful manner. The questionnaire was pre-tested for its validity before conducting the actual survey. A total of five people were interviewed during pre-test. Following the feedback from pretest and prior discussion with local experts, the final version of the questionnaire was modified accordingly. Those questions that were ambiguous, repeated and difficult to be understood by respondents were reduced from the final version of the questionnaire.

The structured questionnaire of the survey was designed to solicit information grouped in four categories namely; the personal factors, resource factors, perception and social factors

and supply and time factors. The personal factors included age, level of education, gender, farming experience and size of household; resource factors included farm size, rented land size, income, off-farm income, harvesting labor cost, number of oxen, and access to credit/exchange system; perception and social factors included perception, knowledge of mechanization services, neighbor persuasion, institutional factors, norms, fee opinion, work quality, profit orientation; and supply and time factors included distance to main road, number of service providers, uncertainty and brokers role.

Secondary data were gathered from government, non-governmental sources and FAO publications. A focus group discussion (FGD) with eight participants were conducted to generate qualitative information. The main discussion areas addressed during FGD included experience in mechanization service in the area, challenges in accessability, the farm power situation and limitation in the expansion of mechanization services in the area.

3.5. Sampling Design

Both purposive and random sampling were employed for selection of sample farmers from the woreda. Multistage sampling technique was used using both purposive and random approaches. Debre Elias woreda was purposely selected. From the woreda three kebeles were also selected purposely as they represent the major mechanization service use kebeles of the woreda. These kebeles were Yekegat, Guay and Tija Goter. These three kebeles were selected based on past highest number of farm machinery usage. The total number of households in the woreda estimated at 22,117. Of which, the three selected kebeles in total have about 3,083 households. According to the report from Debre Elias woreda office of agriculture, about 250 households have used tractor hiring service and about 8,000 households used combine harvesting service in the year 2018/19. The total number of households in the sampled kebeles is 3,083. Yekagat kebele have 995, Guay 1,261 households and Tija Goter 827 households.

The sample size (interviewees) selection was determined following the normal sampling procedure used in various studies (Cochran, 1977). Thus, for this study the following formula to calculate sample size was used:

$$n = \frac{N}{1+N(e)^2} \qquad \text{(Eq. 1)}$$

Where:

n= designates the sample size the research uses;

N= designates total population;

e= designates maximum variability or margin of error (for this study 8% is taken);

1= designates the probability of the event occurring.

A total sample size composed of 148 household farmers was selected to collect data and analysis. After data entry and cleaning fifteen observations were found to have insufficient information. Hence, the final data analysis and reporting was based on a total of 133 households randomly selected from the three kebeles.

3.6. Methods of Data Analysis

Data analysis employed both descriptive and econometric methods. The descriptive analysis was used to summarize some important socio-economic characteristics of the interviewed households. This method included the application of means, percentages and standard deviations. The econometric model was used to measure the significant level of the mentioned factors and its impact on hiring decision of farmers for mechanization services.

The collected data from the survey were coded, summarized and processed for analysis. The quantitative data were analyzed using Statistical Package for Social Sciences (SPSS).

3.6.1. Specification of the Econometric Model

The Classic Regression Method (OLS) cannot be used because normality hypothesis is distorted when dependent variables are categorical (1, 2 and 3) and puppet variable (0, 1) is available. That is, OLS results in neutral and effective assumption values depends on that the variable is constant. LOGIT and PROBIT models are used when dependent variables have puppet value. In these models, interrupted variables turn into continuous ones based on the probability distribution (Gujarati, 1995). In most applications the models are quite similar, the main difference being that the logistic distribution has slightly fatter tails. In practice many researchers choose the logit model because of its comparative mathematical simplicity (Gujarati).

The logistic regression model is one of the most common approaches used to study the decision between two alternatives (Field, 2005). This model predicts the probability that an

individual with certain socio-economic characteristics and other determinants chooses one of the alternatives (Gujarati, 2003; Field, 2005).

A binary logistic model was used to estimate the relationship between factors and farmers' decision towards hiring of agricultural mechanization services. Farmer's take the hiring decision based on the utility level perceived from mechanization. In other words; farmers decide to hire a mechanization service if he or she perceives the maximum utility and benefits.

Following Gujarati (2003), the logistic regression model form for binary choice problem could be introduced as:

$$\ln \frac{Pi}{1-P_i} = \beta_0 + \sum_{j=1}^{k} \beta_j \chi_{ij} \qquad \text{(Eq. 2)}$$

The model specification for the analysis is given as: $Y=f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \ldots X_n)$

Where Yi denotes the dependent variable, representing a hiring decision for the i^{th} household. Farmers decision towards hiring a mechanization service (those who decide: 1 and those that do not:0), X_{ij} constitute the independent variables in the study, β_0 = constant term and β_j=coefficient.

Pi is assumed to be the probability that decision is made to hire mechanization services and, therefore, $1-P_i$ represents the probability of not hiring mechanization services.

$P[Y=1] = P_i$

$P[Y=0] = 1-P_i$

The ratio $P_i/1-P_i$ is known as the odds ratio in favor of hiring a mechanization service.

The logistic model applies the maximum likelihood estimation after transforming the dependent into a logit variable. The empirical mathematical model for estimations is formulated as follows:

$$P_i = prob(Y_i=1) = \frac{1}{1+e^{-(\beta_o+\beta_1 X_{1i}+\ldots\beta_k X_{ki})}} = \frac{e^{(\beta_o+\beta_1 X_{1i}+\ldots\beta_k X_{ki})}}{1+e^{(\beta_o+\beta_1 X_{1i}+\ldots\beta_k X_{ki})}} \qquad \text{(Eq. 3)}$$

Based on the empirical model presented in Equation (2), the effect of explanatory variables on farmer's decision to hire mechanization services could be expressed through the following linear relationship:

The regression probability is:

$$\text{Ln } P_i/1\text{-}P_i = L = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n$$

Therefore, for estimation purpose, variable Y is defined in this study as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots. + \beta_{24} X_{24} + \varepsilon$$

Where:

Y=Hiring of mechanization services (0 = no decision, 1= hiring decision)

X_1 = Farmer's gender (0 = female, 1=male)

X_2 = Household head age (number)

X_3 = Farmer's education (0=illiterate, 1=literate, read and write)

X_4 = Farming experience (years)

X_5 = Household size (number)

X_6 = Farmer's economically active labour household size (number)

X_7 = Farm size (in hectares)

X_8= Size of rented-in land (in hectare)

X_9 = Wheat land (in hectares)

X_{10} = Off-farm income (No=0, Yes=1)

X_{11} = Number of oxen (in number)

X_{12} = Goal of farming (1= Seed production, 0= otherwise)

X_{13} = Did you hire tractor because of labor shortage (Yes=1, No=0)

X_{14} = Did you hire tractor because of better land preparation and faster operation? (Yes 1, No=0)

X_{15} = Farmers hire services with neighbor's influence (Yes =1, No=0)

X_{16} = Farmers hire services with institutional influence (Yes=1, No = 0)

X_{17} = Farmers hire services with broker's influence (Yes=1, No=0)

X_{18} = Did you hire combine harvester because of high labour cost (Yes=1, No=0)

X_{19} = Farmers hire due to uncertainty (Yes=1, No=0)

Some of the factors that were stipulated in the conceptual framework are not included in the model since almost all farmers in the study area responded 'yes' and some factors such as distance of the farm location were difficult to measure. No significant difference was observed among respondents with regard to the perceived hiring rate of mechanization services. For variables such as 'hiring rate', none of the respondents perceived it as being low, hence even though it was an important variable it was omitted from the regression analysis.

Goodness of Fit Test

It is also called Hosmer-Lemeshow test which represents a X^2 (Chi-square) test used for testing the adequacy of the model for fitting the data. The null hypothesis is that the model is adequate to fit the data and we will only reject this null hypothesis if there are sufficiently strong grounds to do so (traditionally if the p-value is less than 0.05). The degree of fit of the model to the observed data is reflected by the -2Log likelihood value. Large values of the log-likelihood statistic indicate poorly fitting statistical models, because the larger the value of the log-likelihood, the more unexplained observations there are (Field, 2009).

Likelihood Ratio Test

The test depends on –2log likelihood ratio. We use this test for checking the significance of the difference between the likelihood ratio for the reduced model with explanatory variables and the likelihood ratio for current model with only a constant in it. Significance at 0.05 level or less means the reduced model with the explanatory variables is significantly different from the one with the constant only (all 'b' coefficients being zero). It measures the enhancement in a fit that the explanatory variables make compared to the null model. Chi-square is used to evaluate the significance of this ratio. When probability unable to reach the 0.05 significance level, we do not reject the null hypothesis that knowing the explanatory variables has no more effects in predicting the response variables.

Measures of Goodness of Fit Test

In linear regression method and depending on OLS, we use the coefficient of determination R^2 as a measurement of goodness of fit, which represents the variation ratio which explained by the model. Using logistic regression, a similar statistic does not exist, and therefore several pseudo-R^2 statistics have been developed. In this paper, we will depend on three pseudo R^2 values: Cox and Snell R^2, Nagelkerke R^2, and McFadden R^2.

Statistical Significant Test

In linear regression, we want to know how the model overall fits the data but also to determine the contributions of the explanatory variables. In logistic regression, we use another tool called Wald statistic, which is similar to the t-test performed on the coefficients of regression in a linear regression to test whether the variable has a real contribution to the prediction of the outcome, specifically whether the coefficient of explanatory variables is significantly different from zero. To evaluate the fit of a logistic regression model, we use the area under the curve which ranges from 0.5 and 1.0 with larger values indicative of better fit. (Kleinbaum and Klein, 2010).

3.6.2. Definition of Variables and Hypothesis

The variables that were used in the analysis are defined as follows. Based on the literature reviewed, it was hypothesized that farmers decision to hire mechanization services can be influenced by combined effects of various factors. The agricultural mechanization services contracted in the woreda were divided into two main types which are: a) tractor and implement for land preparation, b) combine harvester services.

Decision (Dependent Variable): Farmer's decision to hire mechanization services.

Personal Factors

Gender: Respondent's gender. For female households, across sites and household types, hiring labor and animal drafts are the most common ways to reduce labor burdens (Eerdewijk and Danielsen, 2015). Women farmers are more willing to use tractor services as compare to male farmers due to time constraint to finish land preparation on time, as they have to share their time for household activities. Hence, it was hypothesized positively for female households.

Age of the Farmer: Age of the household head (years). The age of the farmer was hypothesized to be negatively related to the hiring decision for machinery services. This is because old farmers are more suspicious about new technologies than young (Shiferaw and Holden, 1998). Older farmers have more experience in farming accumulated through experimentation and observations. Because of this, they may find it difficult to abandon their traditional practices for new technologies.

Level of Education*:* Education of household head (years). Level of education was assumed to increase a farmer's ability to obtain, process, and use information relevant to the hiring of mechanization service decision. Illiteracy is a big barrier to adoption as it limits the level of thinking, understanding, and dormant to adopting new technologies capable of improving their current state of living (Ayandiji A and Olofinsao O.T. 2015). Hence, education was hypothesized positively to increase the probability of utilizing the machinery hiring services.

Farming Experience: Years of farming experience. The farmer in the entry and growth stages might display increasing productivity with improved managerial ability. Longer farming experience have a higher significant relationship among factors that explain the behavior of agricultural innovation adoption (Huang, 2018). More farming experienced was hypothesized to have a positive effect on the hiring decision.

Economically Active Household Size: Number of people with age range of 15-60 years living in one household. Larger families will be able to provide the labor that is required for farming operations. Farmers with large household sizes may not be interested in hiring tractor because the able and grown-up ones can be used as farm labour (Julius, 2014). So, it was hypothesized to be negatively related to hiring mechanization services.

Resource Factors

Farm Size: Total cultivated land (ha). To pay for hiring services, the farm size is the crucial matter. The amount of cultivated land per household significantly affect the technology use status of the household (Challa, 2016). Farmers having a large farm can afford to pay than others. So, it was hypothesized to positively associate with the hiring decision.

Farm income: Level of farm income(earning) per year. A good income could serve as cash source to buy mechanization services. Farm households who have higher income are willing to use tractor hiring services (Takele et al, 2018). Hence, it was hypothesized to have positive influence on hiring decision.

Off-farm Income: Income generated outside the farm. Off- farm income is expected to provide farmers alternative source of liquid capital for purchasing productivity enhancing inputs (Diiro, 2009). An increase in the non-farm income of the farmer will increase the capital available for him or her invest in hiring mechanization services. It was hypothesized to positively affect his/her decision to hire. It also decreases the risk of spending money on mechanization services if farming will fail.

Labor Cost: Labor cost of harvesting per ha. During the peak season, due to limited labour availability, farmers would go for mechanization of particular operation. The relative shortage of rural labor is the prerequisite for the development of agricultural mechanization (Wei Li, Xipan Wei et al, 2019). Hence, it was hypothesized that labour shortage will positively influence farmer's hiring decision.

Number of Oxen: Number of oxen owned by individual farmer. Shortage of oxen was hypothesized to be positively related to the probability of hiring mechanization services. This is also correlated to the cost involved to keep oxen in the farmstead. Farmers owning many oxen might find it burdensome to keep oxen and are open to alternative options (Takele and G.Selassie, 2018).

Rent-in Additional Land: Size of additional land rented in by household. Farmers who rented in additional land was hypothesized positively to make machinery hiring decisions.

The presence of households with large farm sizes and the potential for area expansion suggests that mechanization is more likely to be feasible (Diao et al., 2016).

Wheat Land*:* Size of land dedicated for wheat by individual household farmer. The profitability of use of combine-harvesters is higher in the case of wheat compared to other crops (Berhane et al., 2017). Hence, it was hypothesized that the existence of more land allocated for wheat production to positively influence the hiring decision of farmers for mechanized operations.

Perception and Social Factors

Fee Opinion: Farmers' opinion about the cost of hiring. High cost of hiring negatively influence the farmer's hiring decision. Having high costs is considered to be a hindrance to the adoption

of some technologies (Mwangi and Kariuki, 2015). Hence it was hypothesized that a high cost perception will negatively influence the farmers' hiring decision.

Goal of Farming: Whether the farmer is a seed producer or not. If the goal of farming is to produce seed, they use improved seed and produce it for sale. Farmers who are involved with higher value cash crops are likely to invest in 'new' technologies and mechanization (Kahn et al., 2018) High yielding varieties are mostly improved and will require better land preparation and may influence the farmer to go for tractor mechanization services. Hence it was positively hypothesized.

Quality of Work: Farmers' opinion about the quality of mechanization work and its effect on yield. Agricultural operations when performed by machinery result in better quality than that of animals. The better the quality of work, the more likely that farm machinery will be used. Farmers' perception that tractors do faster operation and assisting in better yields came out on top as a reason for hiring tractor (Baymolt and Zaal, 2015). Hence, it was hypothesized that farmers will decide for hiring machinery mechanization services.

Neighbor Persuasion: Other farmers may influence through the word-of-mouth by exchanging positive information regarding hiring services. Model farmers are well accepted by majority of the farmers, and they have better access to extension workers (Takele and G.Selassie, 2018). Number of farmers who follow who are persuaded by other farmers to hire mechanization services were hypothesized positively.

Brokers: Role of brokers to influence the hiring decision of farmers. The role of brokers is in making the hiring process easier and quicker (Man N. and Mat Zain N., 2014). Brokers manage and try to maintain or expand the area under their supervision. They try to influence

the farmers to use their services or those of their service providers. Hence, it was hypothesized that farmers will decide to hire mechanization services if brokers are involved.

Institutional Influence: Role of extension to influence the hiring decision of farmers. Access to extension service is seen to have a positive effect on the adoption of agricultural technologies. Access to extension services is essential in promoting modern agricultural production technologies. Agricultural extension and advisory efforts are essential for the success of any mechanization and sustainable farming system (Sims and Kienzle, 2016). Hence, it was hypothesized to influence the hiring decision of farmers for mechanization services positively.

Norms: An agreed-up on, socially acceptable, preferred number of days for field work which the farmer is willing to do farming jobs in a month. Customs, traditions and religion can have a major impact on people's livelihoods, including their choices for – or even opposition to – certain tools, or mechanisation in general (Stroh de Martinez et al., 2016). The number of farmers who allow tractor services on their land for most of the days in a month were hypothesized to have a positive effect on hiring decision.

Supply and Time Factors

Distance: The location of the farm from the main road, in kilo meter. Distance to the main road is correlated with the accessibility of machinery service provider. The further away the farms are from towns and from a road, the more expensive it becomes to fuel the combine-harvesters (Berhane et al., 2017). It was hypothesized to be negatively related to the probability of hiring decisions, since households near to main road tend to have access to information and are easily reachable by service providers.

Service Providers: Number of service providers regularly operating in the area. The presence of machinery service providers in the farmers' vicinity area affects the hiring rate. Adoption is still affected by the presence of tractor owners within the same village district committee (Takeshima et al., 2016). A higher number of farm machinery service providers in the area will mean that mechanization services can be more easily accessed. Hence, it was positively hypothesized.

Uncertainty: Risk of losing yield from unexpected weather change. Mechanization can help farmers perform timely field operations amid changing weather patterns and reduce labor requirements (Diao et al., 2017). Farmers who are in uncertainty were hypothesized to decide to hire mechanization services.

CHAPTER FOUR: RESULTS AND DISCUSSION

Chapter four is further divided in to two sub-chapters; descriptive results and econometric results. In this chapter the results of the study along with previous research findings are briefly discussed.

4.1. Descriptive Results

Description of Respondents

The study was composed of 133 randomly selected sample size from three kebeles of Debre Elias woreda, namely Yekegat, Guay and Tija Goter. From all kebeles, 52 (39.1 percent) respondents have hired tractor ploughing services and 78 (58.6 percent) respondents have hired combine harvesting operation. From which, some farmers (20.3 percent) hired both services, 18.8 percent hired only tractor ploughing, 38.3 percent hired only combine harvester and 22.6 percent of respondents hired none of the services. Other tractor mechanization services such as discing and planting are not available in the woreda. There were large number of farmers who hired combine harvester than tractor services. It showed that the uptake of combine harvesting is much more accepted and developed than tractor mechanization.

Table 4.1. Hire Mechanization Services

Characteristics	Percentage
Hire mechanization services	
Only tractor ploughing	18.8
Only combine harvesting	38.3
Both tractor and Combine harvester	20.3
No hire	22.6

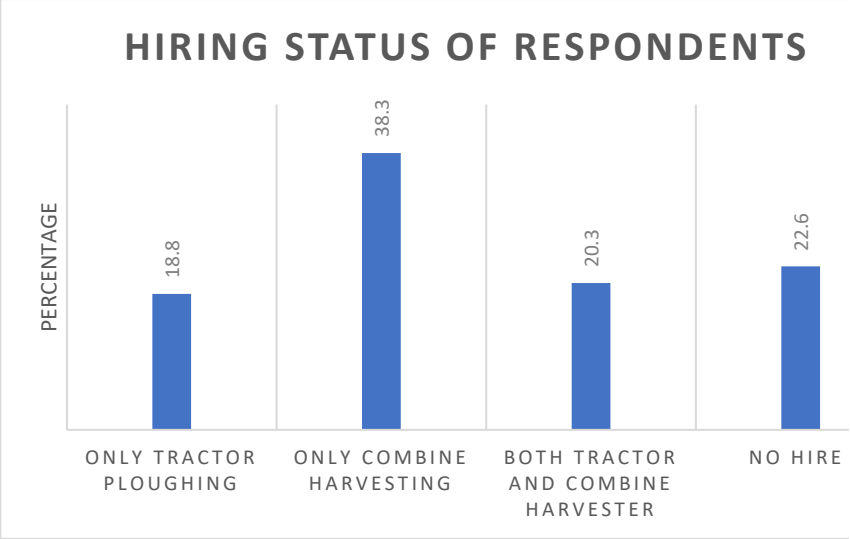


Figure 3 Hiring Status of Respondents

4.1.1. Social and Demographic Characteristics of Sample Households

Sex, Family Size and Age Structure

Data values of the social and demographic characteristics such as gender, age, and number of economically active household member were analyzed using descriptive analysis. By using descriptive analysis, the frequency distribution table shows clearly how the data values affect the variables in this research. Table 4.2 Shows the result of analysis.

Most of the respondents 108 (81.2 percent) were males and only 25(18.8 percent) were females. From respondents who hired mechanization services 86.4 percent (tractor) and 83.3 percent (combine harvester) were male. Majority of the respondents 70 (52.6 percent) were older people with an age group ranging from 41 to 75 years old, while 63 of the respondents (47.4 percent) were in the age group between15 and 40 years old category. The average age of the interviewed households was 43years old. 55.8 percent of households who hired tractor service were in the age group between 15 and 40 years while for combine harvester 51.3 percent were in the age group from 41 to 75 years. Implying that age has insignificant effect to hiring decision of combine harvester. Regarding family size, about 59.4 percent have at least four family members. The maximum household size is 11. About 30.8 percent of the respondents said that they have family size three and four. Only 9.8 percent of the respondents have household size below three. Out of households who hired mechanization services, families with large number (40.4 percent for tractor and 73.1 percent for combine harvester) were dominant. Concerning economically active family size, nearly half (50.4 percent) of the interviewed households said that they do have up to two family members. On the other hand, about 42.1 percent of households have three to four economically active

family members, whereas only 7.5 percent have more than four economically active labour force. From households who hired mechanization services in the past, family size with minimum number of economically active labour were majority (75 percent for tractor and 50 percent for combine harvester).

Table 4.2 Social and Demographic Characterstics

Characteristics	Total	Hire only tractor	Hire only combine harvester	Hire both tractor and combine harvester	No hire
	Percentage	**Percentage**	**Percentage**	**Percentage**	**Percentage**
Gender:					
Male	81.20	16.70	36.10	24.1	23.1
Female	18.80	28.00	48.00	4	20
Age					
15-40 (Young)	47.40	28.60	42.90	17.5	11.1
41-75 (Old)	52.60	10.00	34.30	22.9	32.9
Household size:					
Up to 2	9.80	76.90	7.70	7.7	7.7
3-4	30.80	31.70	29.30	17.1	22
5 and above	59.40	2.50	48.10	24.1	25.3
Economically active family labour involved in farming activities					
Up to 2	50.40	35.80	35.80	22.4	6
3-4	42.10	1.80	42.90	17.9	37.5
5 and above	7.50	0.00	30.00	20	50

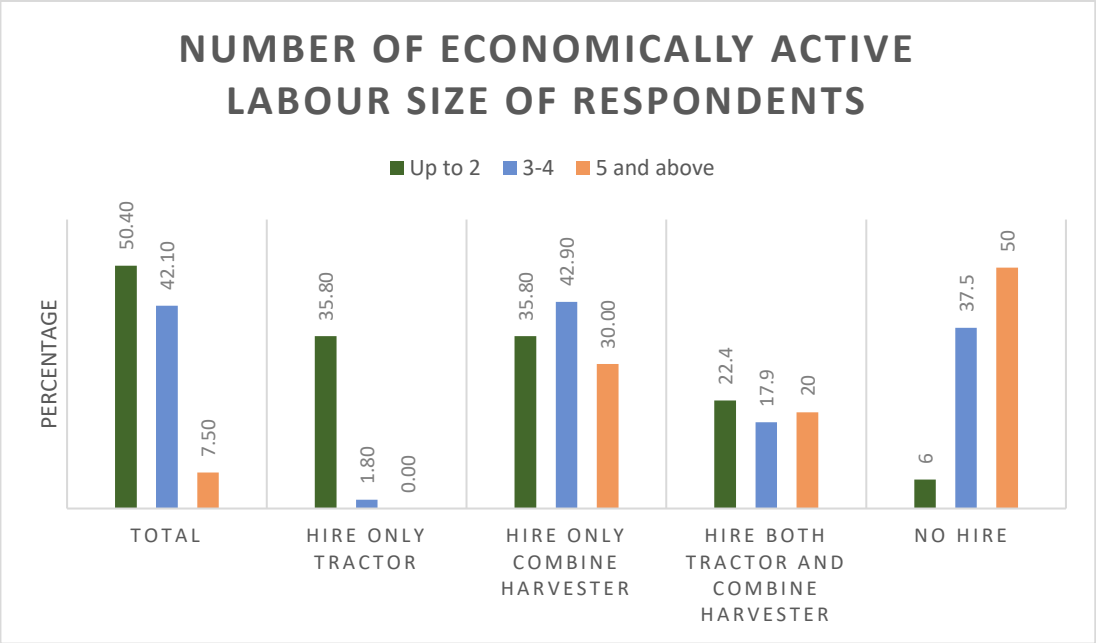


Figure 4 Effect of Number of Economically Active Labour on Hiring

Education Status

From Table 4.3 out of the interviewed households' 33.8 percent were illiterate and 66.2 percent were categorized as literate who can read and write. Among households who hired mechanization services, majority (78 percent) are literate who can read and write. Within the category of illiterate, 46.7 percent did not make any hiring decision, while 15.6 percent hired only tractor service, 28.9 percent hired only combine harvesting service and 8.9 percent hired both services in the last cropping season. Similarly, from those who are literate only 10.2 percent did not hire any mechanization service.

Table 4.3 Education Status of Sampled Household Heads

Characteristics	Total	Hire only tractor	Hire only combine harvester	Hire both tractor and combine harvester	No hire
	Percentage	Percentage	Percentage	Percentage	Percentage
Education level:					
Illiterate	33.8	15.6	28.9	8.9	46.7
Literate, Read & Write	66.2	20.5	43.2	26.1	10.2

4.1.2. General Resource Characteristics

There was wide range of farming experience in the study area, varying from 5 to 50 years. In this study, faming experience was classified into three categories, according to the length of time with agricultural work. The average farming experience of interviewed households was 23 years. In this research, 10.5 percent of farmers had a farming experience of 1 to 10 years while majority (50.4 percent) of respondents had farming experience from 11 to 25 years and 39.1 percent had more than 25 years of experience in farming. Of respondents within farming experience category of 1 to 10 years; 21.4 percent hired only tractor, majority (64.3 percent) hired only combine harvester, 7.1 percent hired both services and only 7.1 percent hired none of the services. Similarly, within farming experience between 11 and 25 years; 25.4 percent hired only tractor services, 43.3 percent hired only combine harvester, 17.9 percent hired both services and only 13.4 percent of respondents hired none of the services during the last cropping season. Majority (38.5 percent) of respondents with farming experience above 25 years did not hire any of the mechanization services.

Table 4.4 Resource Characterstics of Sampled Household

Characteristics	Total	Hire only tractor	Hire only combine harvester	Hire both tractor and combine harvester	No hire
	Percentage	**Percentage**	**Percentage**	**Percentage**	**Percentage**
Farming experience					
1-10 years	10.50	21.4	64.3	7.1	7.1
11-25 years	50.40	25.4	43.3	17.9	13.4
> 25 years	39.10	9.6	25	26.9	38.5
Land size					
Small<=1ha	18.80	16	8	0	76
Big >1ha	81.20	19.4	45.4	25	10.2
Land ownership					
Partially or fully owned	89.50	21	32.8	21.8	24.4
Rented land	10.50	0	85.7	7.1	7.1
Rented in additional land	54.10	12.5	54.2	29.2	4.2
Oxen owned					
None	12.80	64.7	11.8	0	23.5
1-2	32.30	27.9	32.6	25.6	14
3-4	37.60	4	46	16	34
5 and above	17.30	0	52.2	34.8	13
Off-farm income	25.60	41.2	20.6	32.4	5.9

The smallest and biggest land size cultivated by households ranges from 0.5 to 5.25 ha, with the mean of 2ha. 18 percent of respondents cultivate less or equal to 1ha and 82 percent cultivate more than 1ha (Table 4.4). Land size indicated in this study includes all land managed by the farmer. Majority of households with previous experience with hiring of mechanization services had more than 1 ha of land. Among respondents who were operating more than 1 ha of land; 19.4 percent hired only tractor ploughing service, majority (45.4%) hired only combine harvester, 25 percent hired both tractor and combine harvester and 10.2 percent hired no mechanization service at all. Regarding to the farm ownership structure, the percentage of respondents who own their farm was 89.5 percent, followed by 10.5 percent who depend on rented land. Of respondents who relied on rented land, 85.7 percent hired only combine harvester, 7.1 percent hired both tractor and combine harvester. More than half of respondents who rented in additional land also hired mechanization services. From those who rented in additional land, 54.2 percent hired only combine harvester and 29.2 percent hired both mechanization services during the last cropping season. The average

number of plots of the sampled households during the survey period was greater than three in number. This indicates that there is land fragmentation in the area, with the number of plots varying from one to twelve.

Regarding oxen ownership, most of the households' own oxen as it is a major input in crop production process serving as a source of draft power, only 12.8 percent of respondents did not have oxen. There was variability in oxen ownership among farmers in the study area, ranging from one to more than five. From the interviewed respondents 43 (32.3 percent) own one to two oxen, 50 (37.6 percent) own three to four oxen and 23 (17.3 percent) own more than four. Among interviewed farmers who had used tractor mechanization services; 44.2 percent had less than three oxen, 21.2 percent had no oxen at all, 19.2 percent had less than five and only 15.4 percent owned more than four oxen. From the interviewed households with no ownership of oxen; 64.7 percent hired only tractor, 11.8 percent hired only combine harvester and 23.5 percent hired no mechanization service. Within oxen ownership category of more than 5, a large (52.2 percent) number of respondents hired only combine harvester however none hired tractor mechanization services, implying that farmers with no or less number of oxen are likely to hire tractor ploughing services.

Income sources were broadly categorized into two groups; off/non-farm income and farm income. From the interviewed households, 34 (25.6 percent) had additional off-farm income. Of households who had used tractor mechanization services, nearly half had additional off-farm income. From respondents who had an off-farm income; 41.2 percent hired only tractor service, 20.6 percent hired only combine harvester and 32.4 percent hired both. The average farm income of the sampled households was 53,538 Birr per year, during the survey period. The mean farm incomes of households who hired services for tractor and combine harvester are 72,154 Birr and 63,485 Birr per year respectively. This means that farmers with better income are likely to hire mechanization services.

Table 4.5 Total Farm Income in Birr

Characteristics	Frequency	Mean	Std. Deviation
Sampled households	133	53,538	31265.16
Hire Tractor	52	72,154	36,279.08
Hire Combine Harvester	78	63,485.00	34984.65

4.1.3. Perception and Social Factors

The relationship between farmers' perceptions about different attributes and their decision towards hiring agricultural mechanization services was considered by asking different questions about farmers perception and opinion which includes, goal of farming, neighbor's influence, institutional influence, broker's influence, hiring fee opinion and norm limitations. The results as can be seen in Table 4.5 from the surveyed household, 24.1 percent were seed producers while the rest are producing for local market and consumption. From the surveyed households, near half (48.1 percent) who used tractor services were seed producers while among those who hired combine harvester, 29.5 percent were seed producers. Among respondents who were seed producers, 53.1 percent used both tractor and combine harvester services and only 3.1 percent did not hire any mechanization service in the last cropping season. The focus group interview indicated also that mechanized services have especially been taken up by wheat producer farmers.

To exchange information about mechanization technologies with neighboring farmers, a considerable number (39.8 percent) of respondents were not sure, about 8.3 percent had no trust at all and only 51.9 percent had trusted information coming from neighboring farmers. Of all respondents, 21.8 percent of households made hiring decision influenced by other farmers. The result showed that about 33.8 percent of respondents made hiring decision influenced by institutions (extension worker and experts from office of Agriculture) and few (14.3 percent) were convinced by brokers to hire mechanization services, indicating the significant role of extension in bringing positive effect on the adoption of agricultural technologies. Of households who used mechanization services, 53.8 percent (tractor service) and 39.7 percent (harvesting service) said that they first hired the services convinced by government extension workers.

The hiring cost associated with a particular technology is also seen as a factor that influences the decision to hire. Almost all (97.7 percent) of respondents thought that the hiring rate for tractor operation was too expensive and very few (2.3 percent) of households thought that the tractor hiring rate is fair. Similarly, 91.7 percent thought that hiring rate for combine harvesting was too expensive and only 8.3 percent believed that it is a fair rate. From respondents who said the hiring rate of tractor was costly, 18.5 percent hired tractor only service, 38.5 percent hired combine harvester and 20 percent hired both services. The focus group discussion indicated that service rate in the area was relatively higher. Average

service rate for tractor ploughing and combine harvesting were 3,200 to 3,500 Birr per hectare and 100 to 150 Birr per quintal respectively.

Due to religious reasons, majority (75.2 percent) of the respondents did not allow mechanization services to be operated in their farm every day. There are days where no work is allowed in the farm. Of the interviewed households, 6.8 percent said that they do not allow any machinery operations on Sunday's, 29.3 percent don't permit on Saturday's and Sunday's, 40.6 percent don't permit for five to eight days in a month, 18 percent said no operation for nine to twelve days per month and 5.3 percent allowed field operations for only fifteen to eighteen days in a month. In focus groups, respondents indicated that too much no work day in a month is a serious problem. Mobilizing combine harvesters from Arsi and Bale areas to the area was tried in the past. Participants of the FGD said that service providers were unable to work day by day as a result of that they returned back with a loss.

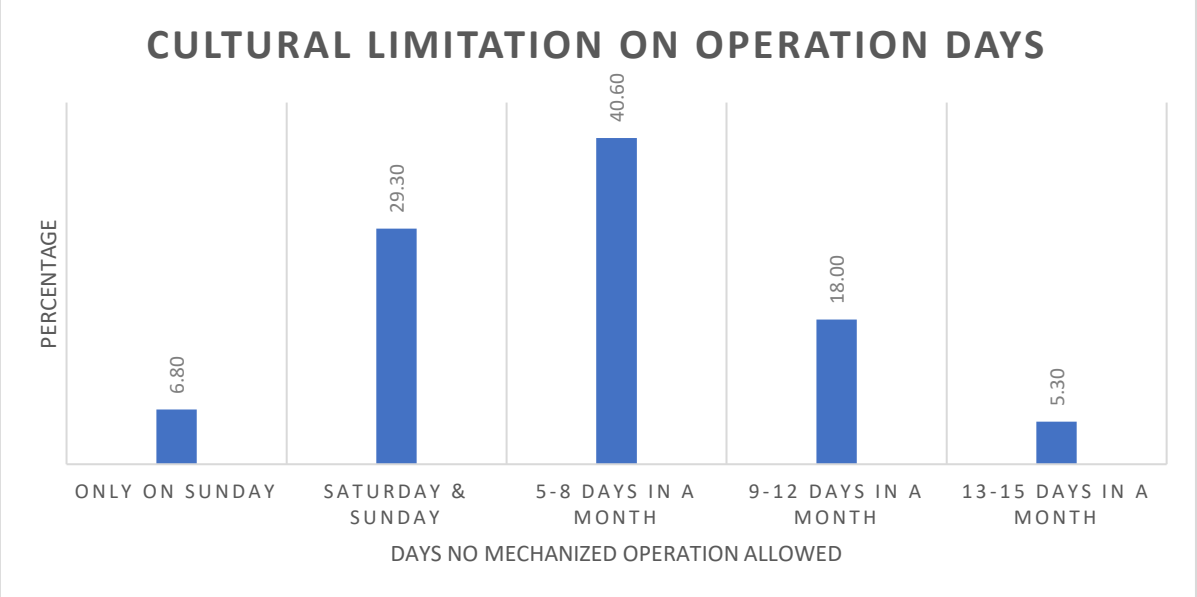


Figure 5 Effect of Cultural Norm in Technology Access

Table 4.6 Perception and Social Factors

Characteristics	Total	Hire only tractor	Hire only combine harvester	Hire both tractor and combine harvester	No hire
	Percentage	Percentage	Percentage	Percentage	Percentage
Goal of farming					
Seed supply	24.10	25	18.8	53.1	3.1
Other	75.90	16.8	44.6	9.9	28.7
Trust neighbors in exchanging information about mechanization					
I trust them very much	21.10	28.6	28.6	35.7	7.1
Yes, I trust them	30.80	24.4	43.9	22	9.8
Not sure	39.80	13.2	39.6	11.3	35.8
I don't trust them	8.30	0	36.4	18.2	45.5
Influence for making hiring decision					
Farmer	21.80	3.4	75.9	17.2	3.4
Institutions	33.80	28.9	35.6	33.3	2.2
Brokers	14.30	36.8	42.1	21.1	0
Fee opinion for hiring tractor ploughing service					
Fair	2.30	33.3	33.3	33.3	0
Costly	97.70	18.5	38.5	20	23
Fee opinion for hiring combine harvesting service					
Fair	8.30	0	63.6	36.4	0
Costly	91.70	20.5	36.1	18.9	24.6
Number of days not permitted for mechanization operations in farmers plot					
Only on Sunday	6.80	0	77.8	11.1	11.1
Saturday & Sunday	29.30	10.3	43.6	28.2	17.9
5-8 days in a month	40.60	38.9	20.4	18.5	22.2
9-12 days in a month	18.00	0	50	12.5	37.5
13-15 days in a month	5.30	0	57.1	28.6	14.3

4.1.4. Supply Characteristics and Uncertainties

Of interviewed households, majority (85 percent) of the respondents got mechanization services from private service providers while 15 percent got from farmers unions and cooperatives. It means that cooperatives provide mechanization services primarily to some of their group members. On average most of the interviewed households farm is located 1.5km away from road with a minimum of 1km and maximum of 10km.

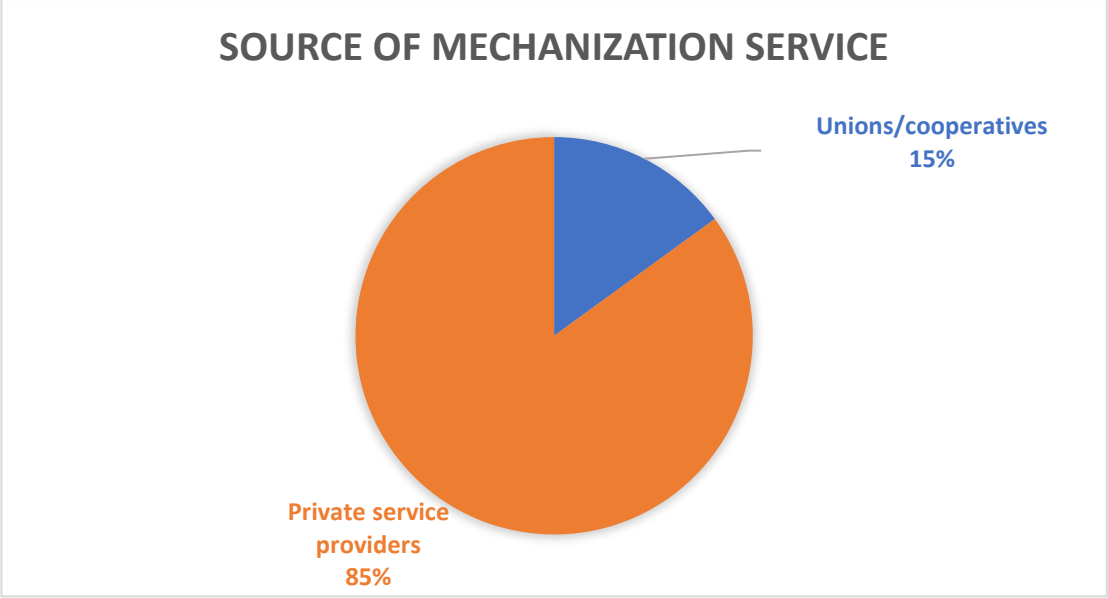


Figure 6 Source of Mechanization Service

Availability of service providers in the area plays significant role in the hiring decision and among the surveyed households. Among respondents, 42.1 percent confirmed the existence of few tractor service providers in their area while 57.9 percent said there are quite very few of them giving service in their localities and a very large group of respondents agreed that they don't get the service fast if needed. The focus group discussion also pointed out accessibility of tractor mechanization services as key factor to make hiring decision. Similarly, respondents said that there are very few (48.1 percent) and few (51.9 percent) combine harvester service providers operating in their area and only quite very few of respondents thought that they can get the service fast when the need comes.

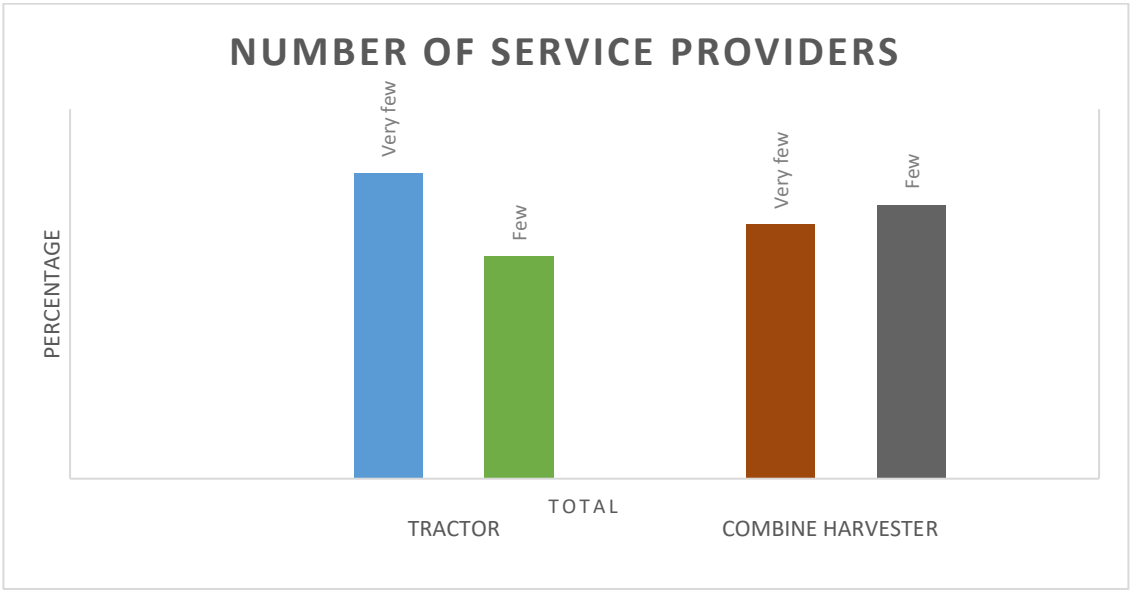


Figure 7 Number of Available Service Providers

Brokers are situated between farmers and service providers. 69.9 percent of respondents reported that there are mechanization brokers in their locality. With regard to role of brokers, 50.4 percent of respondents believed that brokers are not important in the hiring process while 39.8 percent thought that brokers are responsible in making the hiring rate expensive and few respondents (9.8 percent) were in favor of brokers role which they believed that brokers make the hiring process easy and fast. Among respondents who hired mechanization services, 15.4 percent of those who used tractor services and 11.5 percent of those who used combine harvester services thought that they are important in facilitating the hiring process. Of respondents who believed that brokers are important in making the hiring process fast and easy, 23.1 percent hired tractor only service, 30.8 percent hired combine harvester only service, and 38.5 percent hired both services.

Table 4.7 Role of Brokers

Characteristics	Total	Hire only tractor	Hire only combine harvester	Hire both tractor and combine harvester	No hire
	Percentage	**Percentage**	**Percentage**	**Percentage**	**Percentage**
Brokers exist	69.90	23.7	33.3	20.4	22.6
Opinion: Role of brokers in mechanization service hiring					
Not important	50.40	13.4	40.3	17.9	28.4
Make hiring process easy and fast	9.80	23.1	30.8	38.5	7.7
Make service hiring rate expensive	39.80	24.5	37.7	18.9	18.9

4.1.5. Summary of Variables Used in the Model

The variables used in logistic regression model to determine the influencing factors for hiring either tractor or combine harvester mechanization services are summarized here. To draw some picture about the distribution and level of inputs, the percentage, mean and range of input variables are summarized in the table as follows:

Table 4.8 Summary of the Variables Used in the Model

Variables	Min	Max	Mean	St. Deviation	Percentage frequency with Dummy=1	Percentage frequency with Dummy=0
Dependent Variable						
Farmers who hire tractor ploughing mechanization services (Hire=1)					39.1	60.9
Farmers who hired combine harvesting mechanization services (Hire=1)					58.6	41.4
Independent variables						
Gender (male=1, female=0)					81.2	18.8
Education (Literate=1)					66.2	33.8
Age of household (years)	25	70	42.950	9.714		
Farming experience (years)	5	50	23.440	10.180		
Household size	1	11	5	1.928		
Economically active age (number)	0	6	2.590	1.181		
Land size (ha)	1	5.25	1.964	1.037		
Rent-in additional land (ha)	0	4	0.628	0.836		
Number of oxen	0	8	2.950	1.878		
Total area planted with wheat per household (ha)	0	5	1.305	1.096		
Off farm income (1=Yes, 0=No)					25.6	74.4
Goal of farming (1=Yes, seed producer)					24.1	75.9
Neighbor influence (1=Yes)					21.8	78.2
Institutional influence (1=Yes)					33.8	66.2
Brokers influence(1=Yes)					14.3	85.7
Hire tractor due to labour shortage(1=Yes)					22.6	77.4
Time constraint and faster operation(1=Yes)					12	88
Hire combine harvester due to high labour cost (1=Yes)					45.1	54.9
Hire combine harvester due to weather uncertainty(1=Yes)					52.6	47.4

4.2. Econometric Result

This section presents the econometric results of the study. Statistical Package of Social Sciences (SPSS) v.20 software was used to do the logistic analysis and the econometric model results for farmer's decision to hire mechanization services are reported in Table 4.8. Model one is for tractor ploughing hiring decisions and model two is for combine harvester hiring decisions.

Table 9 Results of Logistic Regression Model Analysis

Tractor services Hiring Decision

Variables	Coefficient	S.E.	Wald	Sig.	Exp(B)
Gender of household head	2.587	1.73	2.240	0.135	13.288
Age of the household head	0.17	0.16	1.164	0.281	1.185
Education level of household head	-0.333	1.60	0.043	0.835	0.717
Years of farming experience	0.034	0.12	0.075	0.785	1.034
Economically active labour size	-3.76	1.28	8.583	0.003*	0.023
Total farm land size	1.527	0.80	3.668	0.055	4.603
Size of land rented-in	-1.575	1.01	2.459	0.117	0.207
Number of oxen	-1.509	0.62	6.021	0.014*	0.221
Off-farm income	5.091	2.08	5.967	0.015*	162.546
Goal of farming	3.734	1.80	4.288	0.038*	41.837
Shortage of labour	1.97	2.11	0.875	0.350	7.173
Time constraint and faster operation	2.842	1.78	2.561	0.110	17.143
Broker's influence	1.714	2.19	0.613	0.434	5.551
Institutional influence	2.421	1.19	4.113	0.043*	11.262
Intercept	-2.436	4.59	0.282	0.596	0.087

*Significant at 5% level. -2 Log likelihood=33.461, omnibus tests of Model coefficients (chi-square, df, sig) =144.541,14,0.000) Hosmer and Lemeshow Test=0.999 sig. 0.998 Nagelkerke R square=0.898, percentage of correct predictions=95.5%

Combine Harvesting Services Hiring Decision

Variables	Coefficient	S.E.	Wald	Sig.	Exp(B)
Gender of household head	-1.504	3.22	0.218	0.641	0.222
Age of the household head	-0.178	0.28	0.421	0.517	0.837
Education level of household head	-0.213	1.91	0.012	0.911	0.808
Years of farming experience	-0.169	0.27	0.394	0.530	0.845
Household size	1.879	1.07	3.063	0.080	6.545
Total farm land size	1.113	1.34	0.694	0.405	3.042
Rent in additional land	1.119	1.83	0.375	0.540	3.061
Total area planted with wheat	3.681	1.98	3.472	0.062	39.683
Off-farm income	0.754	4.26	0.031	0.860	2.125
Goal of farming	2.496	4.08	0.374	0.541	12.131
Harvesting labour cost	4.978	2.32	4.595	0.032*	145.231
Neighbor's influence	0.925	1.84	0.254	0.615	2.523
Institutional influence	2.766	2.04	1.832	0.176	15.889
Uncertainty-weather	4.912	2.46	3.995	0.046*	135.957
Intercept	-9.404	7.42	1.606	0.205	0.000

*Significant at 5% level. -2 Log likelihood=16.880, omnibus tests of Model coefficients (chi-square, df, sig) =163.499,14,0.000) Hosmer and Lemeshow Test=0.687 sig. 1.000 Nagelkerke R square=0.953, percentage of correct predictions=97.7%

As a whole, the models performed quite well ($p<0.00$) as indicated by the high value of omnibus test and the lower value of log likelihood. Overall both models predict 95.5 percent and 97.7 percent of the cases correctly. The Chi-square test was used to check the relationship between independent and dependent variables, at 95 percent confidence level ($p<0.05$). The test is 2-tailed (non-directional), and in each case, the null hypothesis (H_o) states that there is no relationship between variables being tested, while the alternate hypothesis (H_a) states that there is a relationship. If the observed p was less than 0.05, the H_o was rejected, and H_a accepted, and vice versa. The log likelihood $\chi 2$ statistics indicates that the composite effect of the independent variables differs from zero ($p=0.000$). Hence, we refuse the null hypothesis and take the alternative hypothesis.

The $\chi 2$ of Hosmer–Lemeshow test indicates that the numbers of respondents who hired mechanization services are not significantly different from those predicted by the model and that the overall model fit is good.

The Nagelkerke R Square (R^2) value measure of goodness-of fit is 0.898 and 0.953 for tractor and combine harvester model respectively.

Evaluation of Results of the Logistic Regression Model

The results in the Table 4.8 found that out of the fourteen selected variables five variables were statistically significant at 5 percent level with respect to hiring tractor mechanization services. Among the selected factors, economically active family labour, off-farm income, number of oxen, goal of farming and institutional influence were found to be important in determining tractor hiring decisions. Similarly, to make hiring decision for combine harvester, out of the fourteen selected variables two were statistically significant. These are higher harvesting labour cost and uncertainty due to weather factors.

Among the personal factors shown above (Table 4.8), the number of economically active labour force in the household was found to have a negative relationship with tractor hiring decisions. It was found that to be significant at the 5 percent level. The finding indicated that households with bigger number of economically active labour force are less likely to hire tractor mechanization services as the excess labour is used for carrying out field operations. This can be interpreted as when other independent variables remain constant,

for every unit increase in number of economically active labour in the household, the odds of hiring tractor mechanization services decreases by 97.7 percent.

The existent of off-farm income of the household exhibits statistical significance ($p<0.05$) to make tractor hiring decisions and is consistent with the hypothesis. Farm household who have additional income from other activities tend to spend much of their time on trading activity or engage in employment opportunities and would prefer to hire tractor services for their land. In line with this, the result indicates that the odds that households decide to hire tractor ploughing services is 163 times more for farmers who had off-farm income. However, the result showed that this variable is statistically insignificant for making combine harvesting hiring decision.

Number of oxen owned was found to be significant ($P<0.05$) at 0.014, but negatively related to tractor hiring decision. This means that the odds of hiring tractor ploughing services decreases by 78 percent for every unit increase in the number of oxen owned. The result of the logistic regression is in line with the hypothesized assumption that farmers who owned more number of oxen tend to use the available animal draft power instead of hired tractor.

Farming goal was measured using a dummy variable; represented by value of 1 for farmers who used their land to produce wheat seed and 0 other wise. The model result for tractor hiring decision showed positive and significant ($p<0.05$) impact and it confirms to the hypothesis that those farmers who are seed producers tend to hire tractor mechanization services. Farmers who are seed producers believed that tractor ploughed fields are better to get a better yield. However, though it has got a positive influence, it is statistically insignificant to make combine harvesting hiring decision.

Institutional influence through government extension system was statistically significant to make tractor hiring decision positively which is in line with the hypothesized assumption. However, this variable was found to be statistically insignificant to make hiring decision for combine harvester. The reason may be that little or no effort is required by extension workers to convince farmers since combine harvesters are well accepted and have higher demand. However, for tractor service, there is low uptake and an institutional influence through government extension service have a role in affecting the hiring decision of farmers. As predicted in the model, the odds of making tractor hiring decision is 11 times more for farmers who said that an extension worker convinced them to hire tractor services.

Higher harvesting labour cost was found to be statistically significant, hence, it influences the hiring decision of combine harvester positively. It was hypothesized that if there are relatively less agricultural laborers, shortage will be created and labour cost would become high then farmers' demands for agricultural machinery operations will be relatively strong. Thus, the result of this study confirmed the hypothesis. The result showed that the odds in favor of hiring combine harvester are 145 times more for farmers who reasoned out a high harvesting labour cost as a cause. However, the model for tractor hiring decision showed that shortage of labour has no significant role to make tractor hiring decision.

The effect of weather factors to make hiring decision of combine harvester was found to be significant. It was hypothesised that uncertaininty from weather is a push factor to make hiring decision of combine harvester. The results of the model confirmed that farmers in general will make hiring decision in order to avoid crop loss due to unexpected rain. The odds of success in hiring of combine harvester due to unexpected weather factors is 136 times higher for farmers who used the service.

At 10 percent significant level, only total farm land size was found to be positively associated with the decision to hire tractor mechanization services. The model predicted that for every unit increase in the total farm land size of the household, the odds of hiring tractor ploughing service increases by five unit. Farm size was hypothesized to have a positive influence to make hiring decision, but it was found to be significant ($P<0.1$) only for making hiring decision of tractors. Though not significant for making hiring decision of combine harvester, respondents who had larger land size tend to hire combine harvesting mechanization services.

At 10 percent significant level, size of household and area of land dedicated for wheat production have significant contribution to make combine harvesting decision. In line with the hypothesis, the model predicted that the odds of making hiring decision for combine harvester service is 40 times more for households who allocates larger plots for wheat production.

Similarly, the odds ratio from Table 4.8 tells us that for every additional number of household member, the likelihood to hire combine harvester service increases by approximately 7 times. The reason for this may be that most farmers with large families are those with higher income level who can afford to hire combine harvester. However, the result suggests further study.

Even if statistically insignificant and has no correlation to combine harvesting decisions, the result suggested that women households are likely to hire the service. Moreover, the model predicted that households headed by men are dominant to make tractor hiring decision. In both model's, level of education has got a negative sign and insignificant to make hiring decision. Although higher education level was postulated to have a positive influence on hiring decision, the findings of this paper indicated a negative relationship - contrary to the hypothesis of the study, suggesting further investigation.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The study analyzed the factors affecting farmers' decision in hiring tractor ploughing and/or combine harvesting mechanization services in three kebeles of Debre Elias woreda, Amhara region. Overall, the survey findings suggest that personal factors such as economically active labour force, resource factors, perception and social factors as well as time factors had explained the circumstances in which farmer decide to hire mechanization service. The decision of hiring for such service is due to the fact that farmers have obtained higher benefits of using the services, which eventually contributed for the livelihood improvement of their families.

The results from the regression model showed that many of the independent variables were significantly associated with hiring decision. In other words, they confirmed the original expectations. The explanatory variables considered had specific role in making hiring decisions. The existent of greater number of economically active labour force within the household has a negative influence in making tractor hiring decision. While other factors such as off-farm income, farm size, the number of oxen owned, the influence by extension personnel/system and goal of farming showed a positive influence on the decision of farmers in hiring mechanization services. The findings of the regression analysis also identified some factors that have significant contribution for farmers to make hiring decision for combine harvester. Shortage of labour resulted in high labour cost, and it influences farmers' decision positively to hire combine harvesters. Push factor from weather uncertainty was identified as one of the significant factors which influenced farmers to make a hiring decision. It was also identified, following the response of interviewed farmers, using combine harvester significantly decreases harvesting costs and improve quality of the product harvested.

Majority of the respondents did not hire tractor mechanization services, there are many who are not convinced of the benefits. Apart from ploughing and some discing operation other tractor mechanization services are non-existent. Majority of the farmers got machinery service from private custom hire operators. Unions and or cooperatives have few

machineries and only serve a small portion, mainly to their members. Thus, there is lack of access specially for tractor hiring services. The number of service providers operating in the study area were few and the service hiring rate for both technologies was relatively higher when compared to other places.

The study has also shown that service providers are not able to fully utilize their machinery in the working days due to cultural limitations. Due to cultural factor, machineries can be under farming operation only for a few days of a month i.e. days agreed/permitted for farming activities in the study area. It is suggested that such practice affects the profitability of service providers by restricting the generation of more sales. Thus, the relatively higher service charge requested in the area might be to compensate and increase service provider's return on investment. Moreover, it may discourage service providers from investing in additional equipment and expanding the service in the area.

An important conclusion coming from the analysis of the surveyed data is the role of extension in influencing the hiring decision of farmers. Most of the farmers who hired mechanization services made decisions following the information they received from extension workers through the existing extension system. In addition, farmers also trust information coming from other farmers. Even though brokers exist in most parts of the research area, most farmers are not convinced of their role. Most of them don't consider them as important actor in promoting the service and to extent farmers also blamed brokers for making the hiring rate expensive. Thus, the findings suggest that demonstration and awareness creation is important for better understanding of the mechanization technologies in order to improve the hiring decision of farmers.

The factors that affect the hiring decision of mechanization services are identified to help various stakeholders to enhance the current level of utilizing mechanization technology by smallholder farmers. This paper can be used to inform the government to develop interventions that would increase the accessibility of mechanization services by smallholder farmers. Interventions regarding institutional support such as availing financial credit for mechanization services, incorporating mechanization support to farmers through extension system and encourage the establishment of support services (small workshops, spare parts shop, fuel stations etc.) are required for the smooth functioning of machinery service providers in the locality.

5.2. Recommendations

Based on the results of the study, the following recommendations are formulated.

- Agricultural extension plays a central role in assisting farmers utilize technologies. It is important that farmers are well informed about the multi-functional use of tractors. New approaches to extension services are recommended through interactive training and demonstrations. Increasing training and demonstration on farm mechanization technologies will increase farmers knowledge on the economic and social benefits and may have a positive effect to decide to hire the services.

- Shortage of economically active family labour were identified as significant to make hiring decision for tractor mechanization services. Due to rapid urbanization, this will continue, and the increase in mechanization use will grow. Hence the custom hire model should be supported to become efficient and accessible.

- Farmers with better off-farm income and total income were relatively better to make hiring decision for mechanization services. Hence, it is recommended to introduce activities that would enhance the income generating capacity of household. In addition, credit and finance should be made available to hire the services with a special arrangement with the service provider to ensure credits are used for the intended purpose.

- Facilitating information and communication technology (ICT) solutions using mobile phones can be used as a means of making accessible mechanization service to farmers. It can facilitate the timely availability of mechanization services. Rural educated unemployed youth who have high aspirations for ICT should be encouraged to engage. Brokers service might also help. Building trust and maintaining satisfaction of farmers is important for brokers to influence the hiring decision of farmers. They need to be supported in facilitating and in making the hiring process short and easy. Training for brokers to make them efficient and more professional is recommended.

- Trust need to be built between service providers and farmers. Availing machinery when it is required and offering quality services to the satisfaction of the farmer are important. Due to the critics of quality of service offered by machinery contractors,

it is recommended to strengthen the skill and knowledge of operators as well as the managers through training.

- Most interviewed farmers responded that apart from ploughing service, no other tractor mechanization service is available. Hence it is recommended to make demonstration and promotion on different tractor mechanization operations such as discing, harrowing, row planting and spraying.

- Improving rural road network is highly recommended for farmers to gain better access to mechanization services. In addition, government should encourage and support the establishment of rural maintenance workshops, fuel stations, spare parts and supplies shops.

- High cost of machinery is one cause for insufficient accessibility. Government policy should support the expansion of agricultural machinery supply through long term loan with low interest rate, subsidy, lease, tax and duty exemption and establishing agricultural mechanization fund. In addition, subsidizing fuel cost used in agriculture would help to minimize the hiring rate of mechanization services.

- Promote cluster-based farming operation for effective use of farm machineries. Accessibility will be enhanced as clusters will give a chance for the service provider to work on more number of plots in one locality. Clustering farmers will also make convenient to organize mechanization services given to a group of smallholder farmers such as tractor spraying operation.

- As uncertainty due to weather is important to make hiring decision for combine harvesters, provision of timely local weather forecasts would help farmers plan and book for hiring services.

- Cultural factors limit the increased use and accessibility of agricultural machinery service to few days in a month. Since society guides the behavior and thoughts of their members, it is not that easy to bring fast change. However, these cultural beliefs may weaken over time. Hence, government-initiated discussions among community leaders, church leaders and other important actors are suggested.

CHAPTER SIX: REFERENCES

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APPENDIX

Interview Questionnaire

Interview Questions

Short self introduction and purpose of doing this research.

The purpose of this questionnaire is to collect data for master's thesis in St. Mary's University from the department of Agricultural Economics. The study is essential for identifying factors that determine farmer's hiring decision for mechanization hiring services, particularly to tractor and combine harvesting services. Genuine responses to each of the survey questions are highly useful. You may choose more than one answer. Responses will be treated confidentially only for this academic purpose.

I highly appreciate your willingness to participate in this survey.

Objectives

1. Identify factors that affect farmers' hiring decision of tractor mechanization services;
2. Identify factors that affect farmers' hiring decision of combine harvester mechanization services;
3. Assess and understand the socio-economic characteristics of farmers for hiring decision;
4. Analyze the respondent farmers' sentiment on key factors in their hiring decision of mechanization services;
5. Identify opinions of experts and local officials on factors limiting the usage of mechanization services in the area and the possible recommendations/suggestions to improve the services;
6. Identify the major sources of tractor and combine harvester hiring for mechanization in the study area;

Survey Region: Amhara **Zone**: East Gojjam **District:**_____ Kebele:_____

Name of respondent:_____

Code:_____

Enumerator's name:_____

Date:_____

A. Basic/general information

1. Age of the household head _____years
2. Sex of the household head a) Male b) Female
3. Educational level of household head
   a) No education
   b) Read and write
   c) Primary (1-4)

d) Secondary school (5-8)
e) High school (9-12)
f) TVET
g) College/University

4. Marital status of household head: a) Never married b) Married c)Widowed d) Divorced
5. Total number of household members _____male_____female
   i. Below 10 years of age_____ male_____female
   ii. 10-15 years of age_____male_____female
   iii. 16 -60 years of age_____male_____ female
   iv. Over 60 years _____male_____female
6. How many of your family members are working:
   - Full time on farm? Male_____ Female_____
   - Part time on farming: Male____Female____
7. How many years have you engaged in agriculture? _____

B. Resource profile of the respondent

8. Do you have own land? a) Yes b) No
9. What is the size of your land in _____*timad* (_____ha)
10. How many plots of land you own? _____
    a) If more than one scattered land, size of each plot_____
    b) On which plots did you hire a tractor or combine harvesting services?
       a) On all b) Partly
    c) If your answer to the above question is 'partly', what was the main reason for not hiring? A) land size too small b) topography sloppy c) located far d) Other reason, specify_____
11. Did you rent-out/share-cropping land during in 2018/2019? a) Yes b) No
    a) If yes, area of land rented out is _____ *timad*
    b) If yes, the reason to rent-out your land is? A) shortage of seeds b) lack of oxen c) shortage of labors d) Others (specify) _____
12. Did you rent additional land during 2018/19 cropping year? a) Yes b) No
    a) If yes, area of land rented is_____*timad.*
13. What types of crop on what size of land have you grown in the production year 2018/2019?

Crops	**Land size (*Timad*)**	

14. For which purpose you have been producing crops? a) selected seed enterprise supply b) industrial raw material supply c) local market d) own consumption e) other specify_____
15. Amount of grain produced and consumed in 2018/19 production season?

Type of land	Produced (Qt)	Consumed (Qt)	Sold(Qt)
Own land			
Rented land			

16. How many times do you plow your farmland? _____
17. Do you own oxen? a) Yes b) No
    a) If yes, Number of farm oxen you have _____
    b) If No, what options do you use to prepare your land? A) borrow from others b) using tractor c) Other specify_____
    c) If no, what are the main reasons for not owning? A) lack of capital to purchase oxen b) lack of animal feed c) high cost of keeping d) Can borrow easily from others d) other specify_____
18. Do you have family labour shortage? a) Yes b) No
    a) If yes, for what were specific activities you have encountered labour shortage? a) land preparation period b) cultivation period c) weeding d) harvesting period e) threshing f) other specify_____
    b) If yes, how do you overcome the problem during peak labour requirement period? a) hiring labour b) labor exchange or *Debo* c) renting out farmland d) family labour e) other specify_____
19. Amount of human and oxen labor allocated in the process of wheat production?

Activities	Animal labour (number)	Family Labour (Number)	Hired labour (number)	*Wonfel* (number)
1st ploughing				
2nd ploughing				
3rd ploughing				
4th ploughing				
5th ploughing				
Sowing and top dressing				
Apply pesticides				
1st weeding				
2nd weeding				
Harvesting				
Threshing				
Transporting				

20. If hiring labour how much is the cost of labour? [Labor cost per day or hectare] a) land preparation_____b) weeding _____c) harvesting_____ d) other specify_____
21. Does any of your children have interest to continue farming as a successor to you? a) Yes b) Not at all c) may be if using mechanization d) Uncertain
22. Do you have financial problem for your agricultural activity? a) Yes b) No
    a) If yes, do you have access for credit from financial institutions? a) yes b) No
    b) If yes, from which financial sources you accessed credit in the past? a) Banks; b) ACSI; c) Saving and credit cooperatives; d) informal lenders in the community; e) others
    c) If yes, can you use the credit to hire mechanization services a) Yes b) No
23. Have you received or got credit? a) Yes b) No
    a) If yes, for what development activities have you received credit? a) To purchase farm inputs b) To rear livestock c) To fatten livestock d) to upgrade farming tools e) Others (specify) _____

    If no, what are the main reason? a) Due to high interest rate b) Shortage of down payment c) lack of land tenure right for collateral d) lack of law and regulation for SHFs loan in financial institutions e) absence of awareness f) Inaccessibility to formal credit institutions g) Other specify _____
24. The main source of household income and livelihood basis is? a) agriculture b) non-agriculture c) remittance d) petty trading e) construction (carpenter, plasterer etc); f) others

25. How much did you get in the year 2018/19(in Birr) from:

Activity	**Income earned per year (Birr)**	
On farm		
Sale of annual crop		
Sale of straw		
Sale of animals		
Sale of perennial crops		
Off-farm income		

26. Do you have any member of your family who engage in off-farm activity? a) Yes b) No

If yes, how many of your family members are working in off-farm activities?
Male_____Female_____ Total_____

C. Social interaction & perception of respondents

27. Do you know about mechanization hiring services? a) Yes b) No
    If yes, - please explain which services are common in your area.
    a) Tractor ploughing
    b) Tractor discing
    c) Tractor planting
    d) Combine harvesting
    e) Others, specify_____
28. From where do you get mechanization hiring services?
    a) cooperatives/union b) government agency c) private service providers d) Another farmer with machinery d) Other specify_____
29. Have you used mechanization tractor and/or combine harvester services in the last two years? a) Yes b) No
    If yes, which of the services you hired in the 2018/19 cropping season?

Type of operation	**Area (ha), *timad***	**Rate (cost /ha), (cost/Qt)**	
Tractor ploughing			
Tractor discing			
Tractor row planting			
Combine harvesting			
Transporting			

30. What was your main reason for hiring tractor mechanization services?
    a) Lack of oxen
    b) Lack of labour
    c) Quality of work-and better yield
    d) Shortage of time- Tractors do faster operation
    e) Less costly
    f) Other specify_____
31. What is your opinion on the yield when comparing tractor prepared field with that of oxen?
    a) No difference b) better c) less
32. What was your main reason for hiring combine harvesting mechanization services?
    g) High labor cost
    h) Lack of labor
    i) Quality of work-less wastage
    j) Shorter harvesting time
    k) Shortage of time
    l) Less costly
    m) Other specify_____

33. Is there more wastage from manual harvesting than combine harvesting? a) Yes b) No c) Uncertain
34. If you hired only for specific operation (eg ploughing), what is your main reason for not hiring other operations (eg. discing, planting) in tractor mechanization services? a) not available in my area b) I don't have cash c) I don't trust the machine d) Personal preference e) other specify_____
35. If additional mechanization services like row planting and spraying services become available, will you have an interest to hire the services? a) Yes b) No
36. How much do you trust your neighbors with regard to sharing ideas on mechanization technologies? a) very highly b) high c) uncertain d) less e) least
37. Do you have any support mechanism with your neighbors? a) Yes b) no
    a) If yes, which one is the support mechanism? a) working in group as *Debo* b) quality seed exchange c) supporting in animal power as oxen d) financial borrowing and lending e) advice and consultation f) Other specify_____
38. Who made you convinced to decide to hire mechanization service for the first time?
    a) neighbors b) extension workers c) brokers d) others specify
39. What is your opinion on the cost of hiring a tractor for different operations?
    - Ploughing a) very expensive b) expensive c) moderate e) cheap
    - Discing a) very expensive b) expensive c) moderate e) cheap
    - Planting a) very expensive b) expensive c) moderate e) cheap
40. What is your opinion on the cost of hiring a combine harvester?
    a) very expensive b) expensive c) moderate e) cheap
41. Do you allow mechanized farming operations to be carried out on your plot every day without any holiday restriction as long as the weather allows?
    a) Yes b) No

    If no, which days of the months are not allowed? A) only Sunday b) less than 5-8 days in a month c) 9-12 days in a month d) 13-15 days e) Other specify__

D. Supply and Time factors

42. Are there many tractors in your area to hire, if you want to get the service? a) Very few (almost zero) b) few c) many
    a) Are they available whenever you need? a) Yes b) No
43. Are there many combine harvesters in your area to hire, if you want to get the service? A) very few (almost zero) b) few c) many
    a) Are they available whenever you need? A) yes b) no
44. How far is your farm from the main road in km? _____
45. The main problem for obtaining tractor hiring service is. a) supply problem b) Price problem c) access and transport problem d) absence of timely supply e) other specify_____
46. The main problem for obtaining combine harvester hiring service is. a) supply problem b) Price problem C. access and transport problem d) absence of timely supply e) other specify_____
47. Are there mechanization service brokers in your locality? a) Yes b) No
48. Did you hire mechanization services through the arrangement of brokers? a) Yes b) No
49. How do you see the role of brokers in mechanization hiring business?

a) Not important b) Make the entire job easier c) Make the service costly d) Other specify_____

50. Did you hire a mechanization service in fear of unexpected weather change?
    a) Yes b) No
    - If yes which service did you hire? A) Ploughing b) discing c) planting d) harvesting e) transporting f) other specify_____
    - If no, what was your main reason for not hiring? A) machinery number not adequate b) No cash available c) other specify_____

E. Description of factors relating to farmers' subjective evaluation on level of the importance of a series of decision variables

51. By putting a √ mark, please rate the level of importance of the following factors for your hiring decision

No	Item	Level of importance				
		Not important at all	Not important	Neutral	Somewhat important	Very important
1	Quality of mechanization work					
2	Weather factors-uncertainity					
3	Role of brokers					
4	Hiring fee					
5	Timely availability of service providers					
6	Opinion of neigbours' on mechanization services					
7	Labour cost					
8	Farm income					
9	Oxen ownership					
10	Perception that tractors and combines do better and faster job					
11	Land size					

Thank you for your answers!