ASSESSMENT OF THE EFFECTIVENESS OF AGRICULTURAL MECHANIZATION SERVICE UTILIZATION: A CASE OF WEST ARSI ZONE, OROMIA REGION

YESHIGETA BAYU AWGICHEW

A Thesis Submitted to the Department of Mechanical Engineering

College of Mechanical, Chemical, and Materials Engineering

School of Graduate Studies

Adama Science and Technology University

June, 2025

Adama, Ethiopia

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Advisor: Amana Wako (PhD)

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Presented in partial fulfilment of the requirements for the degree of master's in science

(Specializing in Agricultural Machinery Engineering)

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DECLARATION

First, I declare that this master's thesis, entitled “Assessment of the effectiveness of agricultural mechanisation service utilization: A case of West Arsi Zone, Oromia,” is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All material sources used for this thesis have been duly acknowledged through citation.

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Name of student	Signature	Date of submission

APPROVAL PAGE OF ADVISOR

I, the major advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Assessment of the Effectiveness of Agricultural Mechanization Service Utilization: A Case of West Arsi Zone, Oromia" Prepared under my guidance by Yeshigeta Bayu and Summited in partial fulfilment of the requirement for the degree of master of science in Agricultural Machinery Engineering. Therefore, I recommend submitting the revised version of the thesis to the department following the applicable procedures.

Amana Wako (PHD)	____________________	____________________
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APPROVAL PAGE OF MSC THESIS

I, the advisor of the thesis entitled "Assessment of the Effectiveness of Agricultural Mechanization Service Utilization: A Case of West Arsi Zone, Oromia" prepared under my guidance by Yeshigeta Bayu Awgichew, hereby certify that the recommendation and suggestion made by the board of examiner are appropriately incorporated into the final version of the thesis.

Amana Wako (PHD)	____________________	____________________
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We, the undersigned, members of the Board of examiners of the thesis by Mr. Yeshigeta Bayu Awgichew have read and evaluated the thesis entitled "Assessment of the Effectiveness of Agricultural Mechanization Service Utilization: A Case of West Arsi Zone, Oromia" and examined the candidate during open defence. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement for the degree of Master of Science in Agricultural Machinery Engineering.

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Finally, approval and acceptance of the thesis are contingent upon submission of its final copy to the School of Postgraduate Studies (SPGS) through the Department Graduate Council (DGC) and the School Graduate Committee (SGC).

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LIST OF ACRONYMS

AMM	Agricultural Mechanization Models
AMMT	Agricultural Mechanization: Machinery and Technology
AMSC	Agricultural Mechanization Service Centers
AMS	Agricultural Mechanization Service
AMSU	Agricultural Machinery Service Utilization
AMT	Agricultural Mechanization Technology
AT	Agricultural Technology
ANOVA	Analysis of Variance
CADU	Chilalo Agricultural Development Unit
DAT	Draught Animal Technology
EPT	Engine Power Technology
FSC	Farm Service Center
FGDs	Focus Group Discussions
GPS	Global Positioning System
GIS	Geographical Information System
HTT	Hand Tools Technology
ICT	Information Communication Technology
MLRM	Multiple Linear Regression Models
MoA	Ministry of Agriculture
MSC	Mechanization Service Center
MS	Mechanization Service
MSU	Mechanization Service Utilization
MT	Mechanization Technology
NGOs	Non-Governmental Organizations
PTO	Power take-off
QoS	Quality of Services
SPSS -V27	Statistical Package for the Social Sciences Version 27
SSA	Sub-Saharan Africa

ABSTRACT

Agriculture is a key economic driver in Ethiopia, whereas Mechanization is a crucial pillar for enhancing agricultural production. Despite mechanization efforts, smallholder farmers can face challenges like limited access, high costs, poor infrastructure, and low awareness, hindering effective utilization of agricultural mechanization services and technology. Key objectives of the research were to assess the current status of agricultural mechanization practices, assess the impact of mechanization services utilization, and propose a tailored service delivery model to address the needs of smallholder farmers. The study used a mixed-methods approach, combining qualitative and quantitative techniques such as surveys, focus groups, and interviews with 150 respondents (126 smallholder farmers and 24 stakeholders). Primary data came from selected woredas of Shashemene, Arsi Negele, Siraro smallholder farmers, service providers, and government offices, while secondary data were drawn from reports and documents. The data analysis was conducted using SPSS 27 version software, and linear regression model was applied to evaluate the impact of various factors on mechanization service utilization critical issues such as the availability of machinery, spare parts, and the training of farmers in adopting mechanized farming practices, offering insights into how mechanization can enhance agricultural practices. The findings reveal that the average age of respondents ranged from 35-50 years, with 56.3% of farmers being illiterate. The analysis revealed that (63%) of the variation in crop production was attributable to mechanization service utilization, and 93.66% of respondents cite the cost of technology as a major barrier to adoption, while the lack of skilled operators and spare parts presents further challenges. In conclusion, this study underscores the importance of agricultural mechanization in enhancing production and productivity in the subsistence farming sector. The study reveals that while mechanization significantly contributes to production and productivity. The challenges, such as limited access to machinery, a lack of skilled operators, and spare parts, hinder its widespread adoption. The research emphasizes improved access to mechanization services, more affordable pricing, quality training for operators, and better financial support systems. The study recommendations include expanding agricultural mechanization in rural areas by improving service access, improving technical capacity, enhancing financial support, and strengthening infrastructure and spare part supply systems for sustainable farming practices among smallholder farmers.

Keywords: Agriculture, Effectiveness, Farm machinery, Mechanization, Service provider.

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Subsistence farming, in which a family produces only to feed themselves, dominates agriculture in Africa, especially in Ethiopia. Additionally, farming was the primary source of employment for the majority of people, with 80% of people in Ethiopia and 75% of people in sub-Saharan Africa (SSA) countries working in some capacity. However, production and productivity were extremely low due to inefficient agricultural technology adoption (Workneh et al., 2021).

Mechanization has become increasingly significant as African nations work to boost agricultural production and productivity. A labor-saving technology, mechanization frequently allows farmers to expand their operations where land becomes available and frees up labor for other agricultural tasks or the creation of income off the farm (Aboagye, 2013).

Like another region of Ethiopia, the agricultural systems in Arsi, Bale, and West Arsi were typically labor-intensive. However, there has been a shift toward utilizing agricultural machinery, particularly for crop production. The early promotion of agricultural machinery has sparked interest in mechanical threshing among farmers in these areas since the establishment of the Chilalo Agricultural Development Unit in 1969 (Hassan et al., 2017)

For smallholder farmers in Ethiopia, particularly those in the West Arsi region, where wheat is one of the main crops, agricultural mechanization is essential for increasing their output and earnings. However, the location, demand, and supply of mechanization services all impact the accessibility and availability of various types of agricultural machinery (Nigussie Tefera et al., 2023)

In the study area, farm mechanization is moreover less practiced. The most crucial pieces of mechanization equipment are combined harvesters, four-wheel tractors, two-wheel tractors, engine-driven stationary threshers, and water pumps (irrigation equipment and accessories). The most popular heavy-duty equipment, however, is 4-wheel tractors and combine harvesters, which are utilized by households. Because the soil is too heavy to plough, 2-wheel tractors with little horsepower are inappropriate (Gebiso et al., 2023)

As agricultural mechanization advances, machines are increasingly substituting human labor and animal power, leading to better efficiency in farming. Nonetheless, the financial gains from using such equipment largely rely on achieving cost-effectiveness through large-scale operations (Quan, 2021).

Owners and managers of agricultural machinery must take care of their machines to keep them in good working order. This includes having enough facilities, following preventive maintenance, having skilled operators and well-trained mechanics, having spare parts on hand when needed, and having a well-organized staff that includes agricultural engineers, technicians, storekeepers, operators, and mechanics (Engineering, 2003)

Agricultural mechanized is the process of replacing manual labor with powered equipment and tools to increase production efficiency. It improves farmers' livelihoods by reducing production costs, enhancing productivity, optimizing product quality, and providing timely inputs. High-end farming machinery and equipment, however, are beyond the means of most farmers. Therefore, offering such agricultural machinery as a service could be a useful and different way to boost farm mechanization (CSISA, 2021). Since mechanization helps increase the productivity and efficiency of agricultural resources, it plays a strategic and potent role. Sustainable, competitive, and courteous agribusiness systems and enterprises will be developed with the help of proper and appropriate mechanization (Amalia et al., 2021).

In agricultural production, agricultural mechanization refers to the application of mechanical assistance. Simple hand tools, implements pulled by animals, or highly advanced agricultural machinery driven by electricity could all be considered mechanical aids. Humans, animals, engines, and electrically powered devices are all sources of energy. Productivity is reliant on the power supply (Kelemu, 2015).

Choosing a service provider is largely affected by the quality of technical services, which is a key factor in assessing agricultural machinery service processes. Keeping agricultural equipment in excellent technical shape and ensuring its reliability and longevity relies significantly on the quality of technical services (Logic, 2020).

1.2. Statement of the problem

Agriculture remains the foundation of Ethiopia's economy; however, it is characterized by subsistence farming, limited productivity, and dependence on traditional farm practices. The government, through the Ministry of Agriculture, is actively pursuing the advancement of agricultural mechanization is supported by the import of machinery without customs duties, which facilitates the adoption of new mechanization technologies and improves access to mechanization services. This opportunity has allowed government and private companies, along with agricultural machinery importers, assemblers, distributors, and dealers, to spread various mechanization technologies throughout the country in order to decrease dependence on traditional farming methods.

Therefore, the challenges in utilizing agricultural mechanization services include limited access to affordable machinery. Most smallholder farmers cannot afford agricultural equipment due to high costs and a lack of financing options or rental services. As a result, they are unable to enhance productivity or reduce the labor-intensive nature of their farming practices. Furthermore, inadequate service infrastructure and coverage hinder improvement in mechanization. This situation is exacerbated by the lack of spare parts, limited technical support, socioeconomic factors related to awareness, and the technical capacity of farmers, all of which hinder service delivery. Many farmers are unaware of the benefits or availability of mechanization services, and even when machinery is accessible, they and the operators often lack the necessary training for proper use and maintenance. This leads to inefficient operation and frequent equipment breakdowns. Additionally, topography, soil types, and the fragmented nature of farmers' land holdings further complicate the effective use of mechanization technology.

The research looked at the challenges of agricultural mechanization practices, the status of AMSU on smallholder production and productivity, and the factors influencing farmers' willingness to adopt mechanization technology in selected woredas. The findings from this study will be invaluable for stakeholders involved in the mechanization sector, as it will illuminate the various factors affecting the sustainable operation of agricultural mechanization service utilization for smallholder farmers. Additionally, it will highlight the challenges that smallholder farmers encounter when trying to access and utilize mechanization services, offering suggestions and insights for service providers and government agencies to enhance their offerings.

1.3. Objective

1.3.1. General objective of study

The overall aim of the research is to assess the effectiveness of utilizing agricultural mechanization services and to assess their current status in the West Arsi zone.

1.3.2. Specific objective of study

Based on the main objective, the specific objectives listed below were created:

1. Evaluate the current status of agricultural mechanization practices.
2. Assess how farmers can utilize agricultural mechanization services.
3. Examine the impact of mechanization service utilization on the production and productivity of smallholder farmers.
4. Develop and recommend a suitable mechanization service utilization model tailored to the needs of smallholder farmers in the study area.

1.4. Research questions of the study

Based on the objective, the following research questions listed below were created:

1. What is the current status of agricultural mechanization practices in the study area?
2. What challenges did smallholder farmers face in accessing and utilizing AMSU?
3. What is the impact of mechanization service utilization on production?

1.5. Scope of the study

This research focused on AMSU, which aims to assess the availability, accessibility, and efficacy of mechanization services for smallholder farmers, evaluate the influence of these services on productivity, and identify effective models for enhancing service delivery within rural farming activities.

1.6. Significance of the study

This study provides valuable insights into the effectiveness of MSU in enhancing smallholder productivity, addressing service delivery challenges, and adopting mechanization technology.

1.7. Limitation of the study

This study may have the following limitations regarding data quality, the availability of qualified data, credit facilitation for custom service providers, the establishment of nearby service centers, and examining other mechanization services on a larger geographic scale.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical literature review

2.1.1. Ethiopian agriculture

Farming is crucial for lowering poverty and is the second biggest factor in economic growth. In Ethiopia, farming is mainly done on small plots because of the high population density, with almost two-thirds of people living in rural regions (Analysis & Scale, 2014).

Ethiopia has a total land mass of 1.13 million km^2, where the arable land is estimated to be 51.3 million hectares, out of which the cultivated agricultural land area is 14 million hectares. The country has unique and diverse agricultural-ecological zones suitable for producing a wide range of crops (ATA and EIAR, 2016).

Ethiopian agricultural production is typified by its subsistence focus, low productivity, low level of inputs and technology, absence of market institutions and infrastructure, and extreme susceptibility to rainfall fluctuations. For Ethiopia's overall economic well-being to improve, productivity performance in the agricultural sector is essential (Othieno, L., & Shinyekwa, 2011)

Ethiopia was an agricultural nation where smallholder rain-fed farming, with minimal use of agricultural inputs and better crop management techniques, was the main driver of the economy. Considered the nation's economic growth engine, the agricultural sector continues to be a key driver of economic expansion and a predictor of the desired changes in the other sectors (Deribe et al., 2022).

The majority of Ethiopia's agricultural output is produced by smallholders. The growth of agricultural output is primarily recognized when smallholder farmers achieve high farm returns and productivity. The primary drivers of farm mechanization in developing nations are the need for smallholders' productivity and profitability to rise to implement sustainable farming practices that will boost food production and the sector's efficiency in using inputs (Mengistu, 2022).

2.1.2. Ethiopian agricultural mechanization

2.1.2.1. The status of mechanization in Ethiopia

Agricultural mechanization in Ethiopia has been a focal point for enhancing production and productivity by addressing labor shortages among smallholder farmers. The Ethiopian government, in collaboration with international partners, has initiated several projects to promote mechanization (Cherkos & Olaniyan, 2024).

The government attempted to cultivate 11 million hectares of land with tractors as required by the 10-year strategic plan, while 5 million hectares of land were cultivated with tractors during the "Kiremt" (rainy) season, according to the Ministry of Agriculture (MoA, 2024). Over the past five years, the percentage of farming operations using tractors has increased significantly, rising from 5.7% to 25% today, when they will be automated in 2020. Because of the supply and service delivery of technologies, crop production has increased in areas where agricultural work is supported by technology to increase production and decrease pre- and post-harvest losses.

The success of agricultural mechanization initiatives in Africa, and Ethiopia in particular, depends on everyone involved, farmers, supporters, planners, and policymakers, understanding and participating in these initiatives from a value chain perspective and throughout the whole farming system (Group & January, 2008).

The primary farming method used by Ethiopia's smallholder farmers, who control the majority of the country's arable land, was animal traction. The smallholder farming system has been using drought animal power for a century. However, smallholder farmers have been using tractor-farm technology more and more in recent years, which has come at the expense of draught animals (Daum et al., 2023).

The utilization of agricultural machinery to automate farming tasks enhances the efficiency of laborers in the agricultural sector. Proper mechanization significantly boosts output by ensuring the timely execution of farming activities while maintaining high quality. The energy demands for tasks such as seedbed preparation, cultivation, and harvesting are substantial, rendering traditional human and animal labor insufficient. Consequently, agricultural practices may be only partially executed or entirely overlooked, leading to diminished yields due to suboptimal growth, premature harvesting, or a combination of both (Muhammad Iqbal et al., 2020).

2.1.3. Farm power and source of energy in the study area

Agricultural power was a crucial resource in farming, enabling timely field operations that enhanced land productivity. It is utilized for various machinery operations, including tillage, planting, plant protection, harvesting, and threshing, as well as for stationary tasks such as running irrigation systems, threshers, shellers, cleaners, graders, silage cutters, feed grinders, and winnowers (Power & Aware, 2007).

Access to sufficient agricultural resources, such as labor, machinery, animal power, electrical energy, solar energy, and other renewable sources, was essential for adopting effective farming practices that boost productivity and reduce crop losses (Anonymous, 2008). As the intensity of cropping increases, the window for making improvements shrinks, complicating the tasks of harvesting current crops and preparing seed beds for future planting within a constrained schedule, unless adequate farming resources are available (Massand, 2021).

Agricultural machinery and technology encompass the tools, machines, equipment, and innovations utilized in farming to enhance the efficiency, productivity, and sustainability of agricultural practices. They are intended to supplement or replace manual labor, minimize the time and effort needed for farming operations, and boost overall crop yields (Review, 2023).

Agriculture in Ethiopia is predominantly defined by smallholder farming, where farmers rely on conventional, labor-intensive practices that frequently result in arduous labor. There is an urgent requirement for mechanization to reduce the physical demands of agricultural work; nonetheless, the extent of mechanization in the nation is still minimal. The energy sources utilized for agricultural mechanization can be classified into three categories: (1) Hand tool technology (HTT), (2) Draft animal technology (DAT), and (3) Engine power technology (EPT).

2.1.3.1. Hand tool technology (HTT)

This was the simplest form of farming using human power with basic tools like hoes and sickles. Humans provide the energy (0.1 HP), but it is inefficient and uses a lot of energy for small areas. They operate tools and do tasks like threshing, winnowing, cutting chaff, and lifting water for irrigation (Note et al, 2011).

On average, a human generates approximately 0.1 horsepower (hp). This output does not maintain consistent work efficiency, indicating a low level of effectiveness. Advantages include: (2) Readily accessible and applicable for various tasks. Disadvantages include: (1) It is the most expensive form of power relative to other sources, exhibits very low efficiency, necessitates complete maintenance when idle, and is influenced by weather and seasonal changes.

It is primarily utilized in different countries for distributing seeds and fertilizers, planting, transplanting rice and vegetable seedlings, spraying with knapsack sprayers, weeding, inter-culture, creating ridges, leveling, and forming bunds with hand tools. Additionally, it encompasses harvesting crops with sickles, picking fruits, gathering vegetables, bundling collected crops like fodder, transporting supplies to the field and harvested crops to threshing locations, threshing crops by striking them (including against a log), moving produce to drying areas and homes, and bagging and loading onto transport vehicles (Akter et al., 2019).

It refers to the physical work done by humans in performing agricultural tasks such as planting, harvesting, tilling, or hauling. This method is the most traditional and labor-intensive form of agricultural work.

2.1.3.2. Draft animal technology (DAT)

Draft animals- usually animal teams controlled by one person, conveniently maintained and trained. Animals are the main source of power. Animal power (rated between 1-5 HP) is superior to manual labor, offers a greater capacity for tools drawn by animals, but is susceptible to tsetse fly infestations and competition from humans for meat and milk.

In numerous nations, the utilization of animal draft power remains prevalent for various agricultural tasks, including tillage, sowing, inter-culture, irrigation (water lifting), threshing (trampling), and transportation activities (Birthal & Rao, 2002).

According to FAO (2010), animal power is a key energy source for farms worldwide, providing about 80% of the draft power in agriculture. Benefits include easy availability, versatility for various tasks, low startup costs, manure production for fields, and reliance on farm produce. However, drawbacks include inefficiency, weather dependency, limited working hours, maintenance needs during downtime, poor hygiene near living areas, and slow work pace.

2.1.3.3. Mechanical power or engine-power technology (EPT)

Engine-powered machinery technology includes various sizes of tractors that serve as mobile power sources for agricultural tasks. These machines, which operate on petrol, diesel, or electricity, include threshers, mills, irrigation pumps, grinders, aircraft for spraying, and self-propelled equipment for producing, harvesting, and managing different crops. With a power rating between 10 to 200 HP, mechanical power can efficiently cover larger areas of land, offering high productivity, though it tends to be costly and requires skilled labor. This technology represents the third major source of farm power, primarily provided by tractors and oil engines (Gifford, 1981).

The majority of engines utilized are diesel engines, which serve to operate stationary machinery such as water pumps, threshers, winnowers, cleaners, graders, and various processing equipment (Biggs & Justice, 2015).

Electric motors serve as the driving force for stationary equipment, including water pumps, threshers, winnowers, cleaners, graders, and various processing machines (Mousazadeh et al., 2009).

Two-wheeled, single-axle tractors primarily serve the purposes of tillage and transportation. When a two-wheeled tractor is fitted with a rotary tiller, it is typically referred to as a power tiller. Additionally, the engines of these two-wheeled tractors, utilizing a belt and pulley system, are often employed to operate stationary equipment such as water pumps and threshers (Baudron et al., 2015).

Four-wheel, two-axle tractors are mainly used to run different agricultural tools for jobs like tilling, planting, cultivating, weeding, making ridges, forming bundles, leveling, spraying, cutting, harvesting, and moving goods. Additionally, by utilizing a power take-off (PTO) shaft equipped with a belt and pulley system, these tractors can also drive stationary machinery, including water pumps, threshers, and other equipment (Darshana et al., 2018).

The predominant self-propelled machinery utilized in the area was the combine harvester, primarily employed for harvesting grain crops such as wheat and barley. Additionally, rice transplanters and sugarcane harvesters were increasingly favoured by custom-hire operators. Furthermore, corn (maize) pickers, forage harvesters, and cotton pickers are also being adopted by these operators (Ganachari et al., 2008).

This model involves medium-scale farmers who use machinery on their farms and rent it to neighbouring farmers. It is the most common mechanization approach in the West Arsi Zone. Services are typically offered during peak farming seasons, like plowing and harvesting. Although it improves access to mechanization, the model remains limited in scale and coverage. Challenges include high operating costs, inconsistent service quality, and poor access to spare parts and technical support.

The model consists of a collective of individual farmers who unite mainly to promote their interests. It can take various forms, such as associations and cooperatives, and serves as a valuable way for farmers to combine their resources and enhance their access to agricultural mechanization services. These services encompass all tasks in the agricultural value chain, ranging from tillage to post-harvest processes, including processing and transportation. Initially, the services cater to the needs of members, and subsequently, they are offered to nearby non-member farmers.

Private Service Providers engaged in agricultural mechanization activities, tractor owners offering rental services, agribusiness companies, importers/distributors of farm machinery, and mechanization hire centres (privately owned).

Organized youth groups' service, involved in providing mechanization services, youth cooperatives operating farm machinery, youth-owned tractor rental groups, government-supported youth employment schemes in mechanization, and youth enterprise groups trained in machine operation and maintenance.

2.1.4. Role of mechanization in agriculture

Agricultural mechanization, particularly within the food system, faces numerous challenges in sub-Saharan Africa. It is essential to identify these constraints specific to each location or country and to develop strategies aimed at mitigating them. Such efforts were crucial for fostering the growth of mechanization services that can support all farmers, with a particular emphasis on smallholder producers and other participants in agri-food value chains (Sims & Kienzle, 2016).

Agricultural mechanization is often overlooked despite being a crucial element among vital farming inputs. This process encompasses a range of tools, implements, and machinery that can be powered by human effort, animal labor, or motorized engines. It plays a significant role in enhancing productivity, facilitating the completion of challenging or undesirable tasks, and elevating the quality of agricultural products (Kienzle & Sims, 2014).

Agricultural mechanization involved using different power sources along with advanced tools and equipment to lessen the hard work required from people and draft animals. Its goal is to improve crop yield, accuracy, and the timely use of various agricultural inputs while minimizing losses throughout the crop production process. This was achieved through established practices, including irrigation and the use of high-yield seed varieties, fertilizers, pesticides, and mechanical energy (Verma, 2005).

Agricultural mechanization refers to using different tools, equipment, and machines to improve land development, crop production, harvesting, storage, preparation, and processing on the farm. It depends on three main power sources: human, animal, and mechanical. This area includes the production, distribution, repair, maintenance, management, and utilization of agricultural tools and machinery, focusing on how to deliver mechanization resources to farmers efficiently and effectively (McNuty, 2009).

Mechanization is a term that describes different farming and processing technologies, from simple hand tools to sophisticated motorized equipment. It makes work easier, solves labor shortages, increases productivity and efficiency in farming tasks, optimizes resource usage, enhances market access, and helps mitigate climate-related risks. Sustainable mechanization considers technological, economic, social, environmental, and cultural aspects to promote the sustainable development of the food and agriculture industry.

2.1.5. Needs of mechanization in Ethiopia

Agricultural mechanization refers to the utilization of energy through engines or motorized equipment to facilitate the interaction between humans and materials within a farming production system. This process streamlines labor-intensive tasks, addresses labor shortages, boosts productivity, and may play a role in alleviating challenges associated with climate change (Getnet, 2017).

Agricultural mechanization was essential for several reasons: (1) it enhances labor productivity by incorporating machinery that replaces manual labor, thereby saving labor costs. (2) It boosts land productivity by enabling greater output from the same area of land. (3) It reduces production costs, as the use of machinery can lower expenses or counterbalance the rising costs associated with draft animals or labor. Mechanization contributes to a decrease in the cost of agricultural operations per unit of output. (4) It ensures the timely execution of farm tasks, allowing all operations to be completed efficiently within a short timeframe. (5) It supports the development of agriculture-driven industrialization and creates markets that foster rural economic growth. (6) Finally, it helps to minimize post-harvest losses.

2.1.6. Appropriate agricultural mechanization

Mechanization ought to replace human labor in agriculture, yet Ethiopia has a low degree of mechanization. It is crucial to utilize mechanization effectively for smallholder farmers in the area. Thus, the government and different stakeholders must assist in moving from traditional farming practices to mechanized systems (Kebede et al., 2011).

Effective agricultural mechanization generates employment for service providers and fosters the growth of various businesses within the mechanization value chains. As the demand for mechanization increases, job opportunities expand for mechanics, fuel suppliers, savings and loan associations, and dealers of spare parts (Bossuet, 2018).

The implementation of suitable agricultural mechanization aimed at enhancing labor productivity tends to exert a minimal influence on social structures. This is primarily because farmers can readily switch back to animal traction, as small machinery does not necessitate extensive land consolidation or substantial investment, especially when contrasted with larger machinery. Consequently, there are notable advancements in rural farm mechanization efforts.

2.1.7. Smallholder farmers' challenges in accessing mechanization in Ethiopia

According to Bekabil (2014), research on agricultural mechanization in the food system faces several challenges in sub-Saharan Africa. In each location (or country), these challenges need to be recognized, and plans should be developed to overcome them. This will enable the growth of mechanization services that can help all farmers, particularly smallholder producers and other participants in Agri-food value chains.

2.1.7.1. Topography and soil type

Many farmers worked on plots smaller than one hectare, which are often poorly maintained and less productive. This disorganized layout, along with the fragmentation of land, frequently hinders machinery from accessing the fields easily and consistently. Consequently, this limits the economic use of machinery across different farms. This situation has a considerable negative impact on economic efficiency. In comparison to those with unproductive land, farmers with fertile land experience reduced economic inefficiency when other factors remain unchanged (Paul & wa Gĩthĩnji, 2018).

2.1.7.2. Affordability

Smallholder farmers typically operate with limited resources, which hinders their ability to invest in physical assets, particularly agricultural machinery. In numerous countries, suppliers of agricultural equipment are predominantly located in larger urban centers, as the perceived low demand for such machinery in rural regions does not always warrant the development of distribution networks. Consequently, smallholder farmers frequently face isolation due to significant distances and inadequate infrastructure, particularly concerning feeder roads (Zangeneh et al, 2015).

2.1.7.3. Availability

Tractors and agricultural equipment may be sourced through imports or assembled domestically, each option presenting its own set of challenges. Typically, machinery that is locally assembled tends to be of inferior quality and comes at a premium cost. This situation arises from the nascent state of the machinery manufacturing sector, which is primarily influenced by insufficient demand. Additionally, the supply chains that are meant to assist tractor and agricultural machinery owners with spare parts, guidance, and various services are frequently inadequate, making it difficult for them to access these resources in remote rural regions (Hegazy et al., 2013).

2.1.7.4. Lack of farmer skills

Farmers in Africa, especially in Ethiopia, possess a wealth of traditional knowledge and experience passed down through generations. However, their access to new information is quite restricted. Training for farmers is generally inadequate, and options for additional education are few. Both public and private extension services struggle to reach rural and remote regions due to long distances and limited transportation. Additionally, high illiteracy rates among rural farming communities impede advancements in agricultural production, productivity, and overall farm management (Rubhara, 2020).

2.1.7.5. Constraints within the private sector

The entire farm machinery subsector, which includes manufacturers, importers, distributors, retailers, and rental service providers, encounters various challenges that impede its growth.

Many of these challenges were similar to those faced by other developing subsectors within the private sector. In numerous Sub-Saharan African countries, the private agricultural machinery manufacturing industry was still in its infancy, struggling against international competition and imports, while also being limited by underdeveloped distribution networks. Additionally, the market for mechanization services is just beginning to emerge, with minimal demand primarily due to smallholders' limited awareness of the benefits of mechanized services (Feder et al., 2011).

2.1.8. The influence of mechanization on production and productivity

The mechanization of production also includes mental work. Its primary aim is to increase productivity and relieve people from hard, labor-intensive, and tiring tasks. Mechanized production encourages the efficient and economical use of raw and processed materials and energy, lowers costs, and enhances product quality.

The improvement and replacement of machinery and production methods are closely tied to the mechanization of production. This is also connected to a rise in workers' skill levels, better organization of production, and the use of scientifically organized labor techniques (Koroso, 2016).

2.1.8.1. Cereal crop mechanization

Cereal crop mechanization in Ethiopia was still in its early developmental phase. Currently, there are efforts to mechanize commercial crops in certain areas. Key cereal crops, including wheat, teff, barley, maize, sorghum, and millet, play a crucial role in the agricultural landscape and are fundamental components of the diet for a significant portion of the Ethiopian population. The prominence of cereals in agricultural production remains substantial (Khandai et al., 2021).

2.1.9. Utilization of agricultural mechanization technology

The lack of agricultural mechanization technologies or their insufficient availability emerged as the primary production limitation across nearly all farming systems in West Arsi. In every cluster of farming systems, a deficit in animal feed led to a shortage of farm power, necessitating a shift towards agricultural mechanization to explore alternative sources of inanimate farm power. In regions dedicated to the cultivation of wheat, barley, and teff, farmers recognized the significance of row planting, despite the challenges they faced (Challa et al., 2021).

2.2. Agricultural mechanization service utilization

Agricultural mechanization service (AMS) plays a vital role in ensuring that smallholder farmers have access to agricultural machinery technology, which is essential for the sustainability of agricultural production and productivity (Li & Guan, 2023).

Agricultural machinery services are becoming increasingly vital in the land transfer market, particularly in developing nations. The success of these mechanization services is measured by their ability to enhance agricultural productivity, profitability, and sustainability. This is achieved by lowering labor expenses, improving the timeliness and quality of farming operations, and reducing environmental repercussions (Farmers, 2021).

Generally, Agricultural machinery service providers typically operate at an individual level, offering a range of services that encompass crop production, harvesting, post-harvest activities, processing, and transportation. In many cases, these businesses are owned and operated by a single individual. The management of such a service-oriented business involves the administration of a hiring service that is primarily focused on business operations, distinguishing it from a farmer who may own machinery and occasionally offers services to nearby farmers.

2.2.1. Profitability of agricultural mechanization service utilization

Agricultural mechanization service utilization (AMSU) refers to the delivery of mechanized tools and services to farmers who lack the financial means or access to such equipment. This approach has the potential to boost agricultural productivity, alleviate labor intensity, and strengthen food security. Nevertheless, the success and profitability of AMSU are influenced by various elements, including the balance of service demand and supply, the costs and accessibility of machinery, the quality and dependability of the services offered, as well as the surrounding institutional and policy framework (Issaka Etal, 2022).

Agricultural mechanization services (AMS) have become a practical and efficient means for farmers in developing nations to obtain access to machinery and equipment (Lu etal, 2022b).

2.2.2. Agricultural mechanization services utilization: Mechanization model

Agricultural mechanization refers to the use of machinery and technology to enhance farming efficiency and effectiveness. The mechanization model illustrates the organized system through which farmers access mechanization services. A significant portion (45%) of survey participants obtain mechanization services from providers or through rental options, while only 20% own machinery for their farming, and 35% have acquired it from their manual farming activities (Figure 2.1). This trend is particularly evident in the West Arsi zone, which includes Shashemene, Arsi Negele, and Siraro woreda, where many smallholder farms exist.

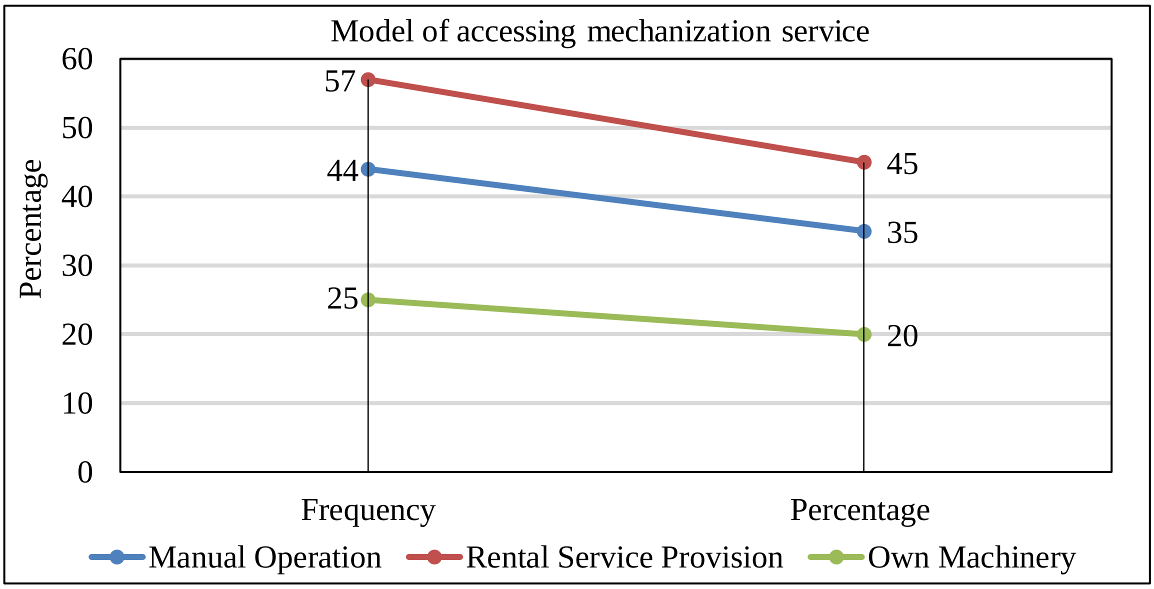

Figure 2. 1. Model of accessing mechanization service utilization

2.2.3. Models of agricultural mechanization services utilization

To ensure that agricultural mechanization is available to everyone, particularly smallholder farmers, it is essential to address several significant challenges. These include making mechanization affordable, enhancing capacity development, improving rural infrastructure, and incorporating information and communication technologies (ICT). In Ethiopia, many smallholder farmers struggle to invest in machinery and equipment, underscoring the urgent need for sustainable business models that can support the use of mechanization services (Sims & Kienzle, 2016).

2.2.3.1. Business models for mechanization services utilization

This research examined various private-sector business models that offer agricultural mechanization services utilization, specifically concentrating on the West Arsi zone, including the Shashemene, Arsi Negele, and Siraro districts. The models identify key success factors and provide insights into government initiatives. The classification of these models is based on ownership structures, such as farmer groups and individual entrepreneurs, as well as the range of services offered, which includes mechanization services, ancillary services, and intermediaries within the supply chain (Said et al., 2023).

Table 2. 1. summarizes the mechanization service utilization models in the study area

Variable	Model I	Model II	Model III	Model IV	Model V	Model VI
Ownership	Individual farmer/service providers	Farmer Groups/Cooperatives	Private service provider	Organized youth group service provider	Digital mechanization service utilization	Government-provided service utilization
Services Provided	Agricultural mechanization services or rental services	Agricultural mechanization services utilization	Mechanization & agricultural hiring services	Mechanization system of supply chain services	Mechanization services & digital services utilization	Agricultural Mechanization Services Centre

Source: - Field survey data (2016/17)

1. Model I: Individual farmer/service providers

This model is prevalent in West Arsi, where individual farmers, often of medium scale, utilize machinery for their operations and subsequently provide services to nearby farmers. Following significant farming seasons, these service providers relocated to regions engaged in other agricultural tasks, such as harvesting and threshing. Although this approach addresses immediate agricultural demands, it tends to hinder innovation and is generally confined to small geographic regions (Yarimoglu, 2014).

This model has offered and still offers a way for small farmers to get mechanization services in rural areas; therefore, support for improving this model in practice can be seen as part of sustainable agricultural mechanization development.

2. Model II: Farmer group/Cooperative service providers

This model consists of a collective of individual farmers who unite mainly to support their interests. It can take various forms (like associations and cooperatives) and serves as a valuable way for farmers to combine their resources and enhance access to agricultural mechanization services. These services encompass all tasks in the agricultural value chain, ranging from tillage to post-harvest processes, processing, and transportation. Initially, services cater to the needs of members and are subsequently offered to nearby non-member farmers in the study area (Hanggana et al., 2022)

3. Model III: Private service providers involved in agricultural activities

In the West Arsi zone, the model featuring the Shashemene, Arsi Negele, and Siraro districts showcases private companies that provide a wide array of services, particularly in agricultural mechanization. These enterprises expand their activities to encompass various elements of the agricultural value chain, including the supply of inputs and mechanization services (Mamun-ur-Rashid et al., 2018).

Private Service Providers that engaged in agricultural mechanization activities, like, tractor owners offering rental services, agribusiness companies, importers/distributors of farm machinery, and mechanization hire centers (privately owned). Prominent examples include Kegna Agricultural Equipment Manufacturing and General Trade PLC, along with Kaleb Farmhouse Service, both of which supply tractors and combine harvesters to boost productivity.

4. Model IV: Organized youth group service provider

This model describes an organized youth group acting as a service provider related to agricultural mechanization. This model focuses on employing youth in groups to offer services such as operating machinery, maintenance, and repairs. The community often selects individuals with experience in mechanization to lead the service utilization. While the services provided are primarily on-farm operations, there are advantages in controlling the supply chain of agricultural machinery, particularly with maintenance and repairs (Rudiger et al., 2022).

Organized youth groups' service, involved in providing mechanization services, youth cooperatives operating farm machinery, youth-owned tractor rental groups, government-supported youth employment schemes in mechanization, and youth enterprise groups trained in machine operation and maintenance.

5. Model V: Digital mechanization service utilization

This model is an adaptation of the “Uberization” concept, as intermediaries act as brokers between farmers and machinery owners. These entrepreneurs do not own machinery but use digital platforms to match service providers with farmers, optimizing resource use. Examples of such platforms include Hello Tractor, which connects tractor owners with farmers in need of mechanization services, providing real-time tracking via GPS technology (Services, 2019).

6. Model VI: Government-provided service utilization

In this model, the government directly provides mechanization services at both the national and county levels. The government of Ethiopia has created multiple strategies to promote mechanization among smallholder farmers. This includes technical training, capacity building, infrastructure development (e.g., Mechanization Service Centers), and tax incentives to promote investment in agricultural machinery. While the government’s role is crucial, the most effective model combines both government and private sector involvement, ensuring broad access to mechanization services (Houssou et al., 2013).

2.3. Scalability of mechanization service models in the study area

To scale up the six mechanization service models in the West Arsi Zone and recommend them to other regions, different strategies should be used for each model. For "Model I", individual farmers and service providers need support through access to affordable loans or leasing options to buy machinery. They also need training in machine operation and repair. For "Model II", farmer groups and cooperatives can grow if they get group-based credit, proper training, and support in managing services together. In "Model III", private service providers can expand if the government gives tax incentives, helps with importing machinery, and links them with farmers and markets. "Model IV", which focuses on organized youth groups, can be scaled by giving youth access to start-up machinery and business skills and connecting them with NGOs or government youth programs. "Model V", which uses digital mechanization tools like mobile apps and GPS (e.g., Hello Tractor), can grow if mobile network access improves and farmers receive digital literacy training. Lastly, "Model VI", government-provided services, can be scaled by increasing investment in public mechanization centres and ensuring they are well-managed and available in areas that need them most.

These models are adaptable to different regions depending on farm size, infrastructure, and market access. Group- and youth-based models suit areas with small farms, while private and digital models fit commercial zones. Government services are essential in remote areas. With local assessments, capacity building, and policy support, these models can be effectively implemented across Ethiopia.

2.4. Review of mechanization service utilization models

Agricultural mechanization plays a crucial role in enhancing production and productivity, reducing labor costs, and achieving sustainable development in agriculture. The adoption of mechanization services utilization varies depending on farm size, geographical location, and available resources. In this study, different mechanization service utilization models have been developed to meet the needs of various types of farmers. Table 2.2 shows a review of common mechanization service utilization models, with a focus on their characteristics, advantages, and challenges.

Table 2. 2. Review summary of mechanization service utilization models

Model	Ownership	Service Type	Target Group	Key Challenges
Individual Farmer/Service Provider	Individual (self-owned)	Tractor hiring, land preparation, planting, etc.	Local smallholder farmers, neighbors	High capital cost, maintenance fees, and machinery spare parts
Farmer Groups / Cooperatives	Group-owned (shared assets)	Full-cycle farm services: plowing, harvesting, irrigation	Cooperative members and nearby farmers	Availability of machinery spare parts, variable fuel cost.
Private Service Provider	Private company or commercial farm	Comprehensive mechanized services (fee-based)	Medium-to-commercial farmers and producers	High service fees, profit over service equity, and access to machinery spare parts
Organized Youth Group Service Provider	Youth group (often supported by NGOs or the government)	Custom hiring, equipment operation, basic repair, and digital bookings	Smallholder farmers and local youth	Access to finance, skill gaps, access to machinery spare parts, and equipment maintenance.
Digital Mechanization Service	Individuals/companies use shared technology like GPS	On-demand service booking (tractors, operators)	Farmers with mobile access, youth operators, and tractor owners	Connectivity limitations, low precision agriculture, and low adoption of digitalization
Government-Provided Services	Public sector (state-owned)	Subsidized equipment rental, operator support, extension services	small-scale farmers, remote communities.	low maintenance and inventory system, limited access to finance, and lack of sustainability.

Source: - Field survey data (2016/17)

CHAPTER THREE

MATERIAL AND METHOD

3.1. Introduction

This chapter covers the research methods, data collection techniques, the location of the study, and a description of the study area. It looks into the physical and socioeconomic conditions, agricultural output, the level of mechanization, and the technologies used. Moreover, it highlights the types of data and sources, data collection and analysis methods, access to agricultural mechanization services, production and productivity rates, the adoption of mechanization technologies, the efficiency of agricultural machinery like tractors and combine harvesters, and the time frame for returns based on cropping intensity in the study area. Additionally, it details the data sources used to assess the socioeconomic effects of mechanization on farmers in the chosen woreda.

3.2. Description of the study zone

The study was conducted in East Africa, specifically in Ethiopia's Oromia regional state, within the West Arsi Zone, which is located approximately 251km from Finfinnee. The zone extends from 6°7′55′N to 7°56′55′N latitude and 38°6′55′E to 39°43′55′E longitude (Engda et al., 2024). As of mid-2022, the total population was estimated at 2,929,894. It shares boundaries with the East Shewa zone to the north, SNNPR to the west, Arsi to the northeast, Guji to the south, and the Bale zone to the east. Most areas of the zone have elevations ranging from 1,500- 2,300m (Senbeta, 2009). Shashemene serves as the capital town and administrative center of the zone, covering a total area of 12,409.99 km^2 (Water et al., 2008). The zone comprises 12 districts, 4 urban administrative areas, and 332 peasant associations (Hasan, 2025). West Arsi Zone exhibits a unique rainfall pattern characterized by two distinct rainy seasons. The primary rainy season, referred to as "kiremt," lasts from June to September, while the secondary season, referred to as "belg," occurs from February to April. The soil types in West Arsi vary by specific area, featuring a range of soils such as nitosols (red soils), vertisols (black cotton soils), and various types of aridisols (dryland soils). These soils differ in fertility, texture, and drainage, which can significantly impact agricultural productivity and the farming method employed (Zone & Hunduma, 2022). The socio-economic activities in the rural area include mixed farming, where crop cultivation and animal husbandry are practiced concurrently. The most commonly produced crops in the zone include barley, wheat, sorghum, *Teff*, maize, and potato (Babu et al., 2023).

The three woredas, namely Shashemene, Arsi Negle, and Siraro, were intentionally chosen from the twelve districts within the West Arsi zone of the Oromia regional state. This selection was based on their advanced agricultural mechanization practices, significant production capacity for various grain crops, and the presence of cultivable land. Furthermore, these woredas have embraced farm machinery and technology, distinguishing them from other woredas in the West Arsi zone, which have been the focus of various research initiatives. Consequently, this study was conducted in the selected woredas of the West Arsi Zone.

3.3. Selection of the study site

The initial study took place in the Shashemene district, which is in the West Arsi zone of the Oromia region in Ethiopia. This district is found 250 km south of Addis Ababa. As per the mid-2022 statistical survey, Shashemene's estimated population was 208,368. In terms of geography, the district is located at 12° North latitude and 38° 36' East longitude, with an elevation between 1,600 and 2,800 meters above sea level, covering an area of 467.18 km². Furthermore, the district includes 37 rural kebeles and 8 sub-cities (Bukul, 2018). The main crops grown in their key economic activity, smallholder farming, are wheat, sorghum, maize, teff, oil seeds, and spices (Alemu & Tolossa, 2022).

The second research study was conducted in the Arsi Negele district, located in the West Arsi zone of the Oromia regional state in Ethiopia, approximately 225 km south of Addis Ababa. This district lies between latitudes 7.15° and 7.75° N and longitudes 38.35° and 38.95° E (Belay et al., 2013). The altitude of the district varies from 1500 and 3000 meters above sea level, and as of mid-2022, the estimated total population of Arsi Negele was 347,974 (Mekonnen et al., 2019). The agro-climatic conditions of the chosen study areas are mainly cool alpine and sub-tropical, which makes them ideal for growing cereal crops like Teff, wheat, barley, maize, and sorghum, which are prevalent (Taye, 2021).

The third study was carried out in the Siraro district is found at a latitude of 70 17' N and a longitude of 380 06' E.in the West Arsi zone of Oromia National Regional State. "Loke Heda town is the district's capital, located approximately 60 & 310 km" from Shashemene & Addis Ababa, respectively (Amenu et al., 2013). The district is found in the Great Rift Valley system, having a total area of 674.62km² or 63,710 hectares (District et al., 2020). This report states that the district is located next to the SNNPR-Halaba district to the north, the Shala district to the east, and the Boricha and Fango districts of SNNPR to the south and west. Siraro district is organized into 32 kebeles, which include 28 rural kebeles and 4 towns

(Duba & Mekuyie, 2023). In general, farming in Siraro has a small range of crops. Maize is the main crop, followed by wheat, teff, millet, and sorghum. Like many rural areas in the country, agriculture in Siraro depends largely on rainfall, with only a few areas having access to irrigation (Chinigo, 2008). The total estimated population of the three selected woredas was 763,883.

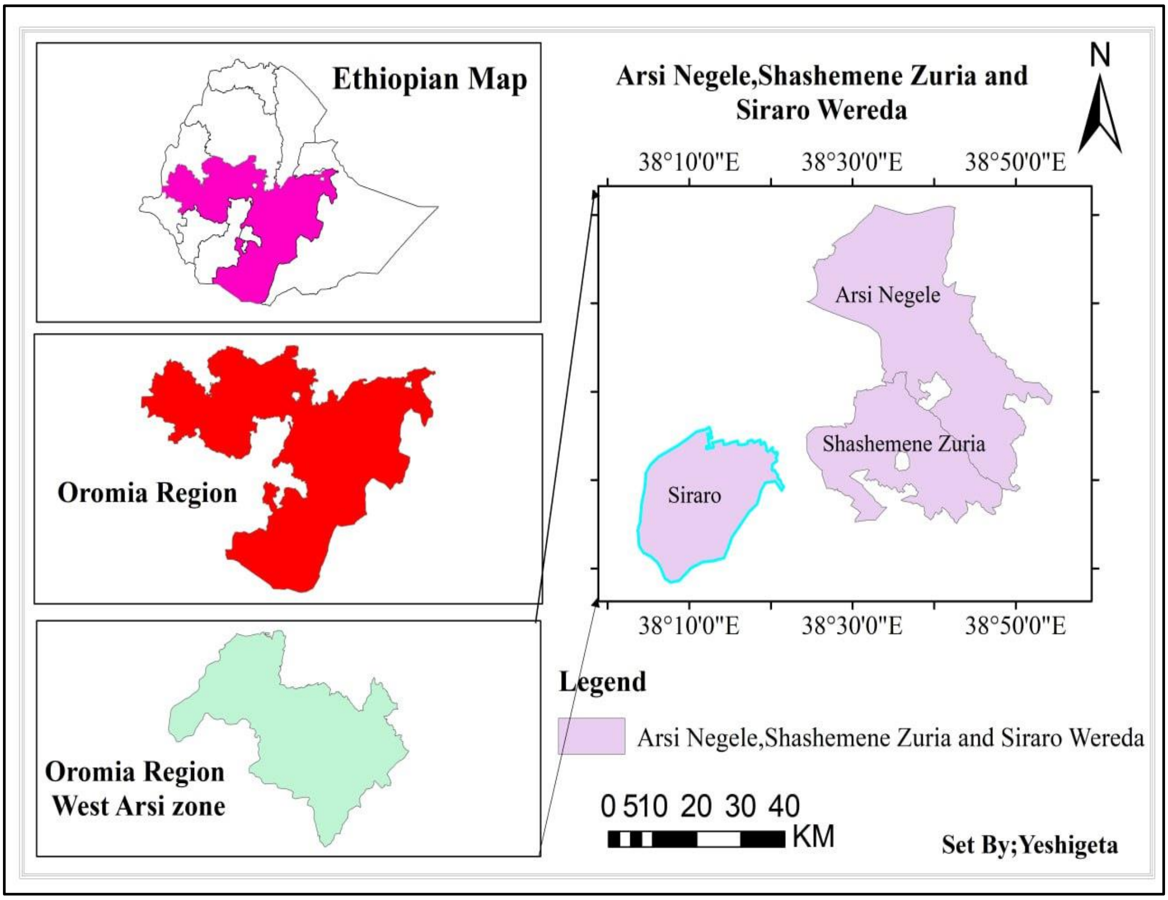

Figure 3. 1. Map of the study area

3.4.Technology suitability of the selected woreda

Shashemene Woreda: The terrain in Shashemene is mostly flat with gentle slopes, and farms are generally medium to large. The area has good road infrastructure, making it suitable for large-scale mechanization. Recommended technologies include four-wheel tractors, disk plows, seed drills, boom sprayers, combine harvesters, and multi-crop threshers. These machines can be efficiently used to cover large areas and improve productivity.

Arsi Negele Woreda: Arsi Negele features flat to moderately sloped land with mixed farm sizes and reasonable infrastructure access. It supports medium-sized mechanized tools that adapt to varying plot sizes. Suitable technologies include four-wheel tractors, disc plows, cultivators, direct seeders, row planters, tractor-mounted sprayers, and threshers. Small combine harvesters may also be effective in flatter areas, helping to enhance labor efficiency.

Siraro Woreda: Siraro features undulating and fragmented terrain with small, irregular farms and limited road access. Operating large machinery here is challenging. Instead, lightweight and portable technologies such as two-wheel tractors (power tillers), animal-drawn plows (maresha), portable threshers, mini tillers, and hand-held tools are more suitable. Cart-mounted water pumps can assist with small-scale irrigation where needed.

3.5. Research design and approach

The surveys were created to gather both qualitative and quantitative information. They encompassed various aspects, including household characteristics, ownership of agricultural technology, practices related to mechanization services, descriptions of plowing methods, and experiences with mechanized agriculture. Before the actual survey, the questionnaire underwent a pre-testing phase to ensure its validity, which involved expert evaluation and oversight from the principal investigators in the field, resulting in modifications to certain questions. Additionally, focus group discussions were conducted across three districts to enhance the data collected during the main survey and to provide further insights into the findings.

Information about the socio-economic features of the study area, agricultural technology types, demographic details, main crops grown, and other relevant subjects was gathered from various published and unpublished documents and reports from multiple organizations. The research used a mixed-methods approach, combining both qualitative and quantitative methods, which involved data collection using a structured questionnaire. To analyze the current agricultural mechanization services, information was gathered from end users, distributors, dealers, private enterprises, and government representatives through questionnaires, interviews, and field observations.

The research aimed to evaluate how farmers view the use of agricultural mechanization services and their effectiveness. Information was collected on socio-economic conditions, demographic details, and elements that affect the adoption of agricultural technology.

The information gathered from various stakeholders in the assembly regarding the availability of spare parts for after-sales service, past challenges in adoption, and potential solutions to improve the use of the targeted technology. Additionally, we conducted physical observations of ongoing activities related to agricultural mechanization technology and collected data from the agricultural office. Our approach aims to address the identified issues by analyzing the factors that influence the utilization, adoption, and effectiveness of agricultural mechanization services in the area under study.

The evaluation of agricultural mechanization services involved collecting responses through structured questionnaires. These questionnaires focused on various aspects, including the operational skills of the owners, the availability of after-sales support, the condition and durability of the machinery, proficiency in operating tractors, the lifespan of the technology, common defects, and the socio-economic background of the users.

3.5.1. Theoretical framework

To meet the study's goals and answer the research questions, both quantitative and qualitative research methods were used. The overall theoretical framework is shown in Figure 3.2 below. The study utilized a mixed-method survey design, integrating both qualitative and quantitative strategies. This decision was influenced by the research objectives, types of data, methodology, and sample size. A case study was carried out in three woredas to assess the effects of agricultural mechanization services on the production and productivity of smallholder farmers. It also examined factors influencing adoption, opportunities, strengths, and the main challenges impacting the use of mechanization services.

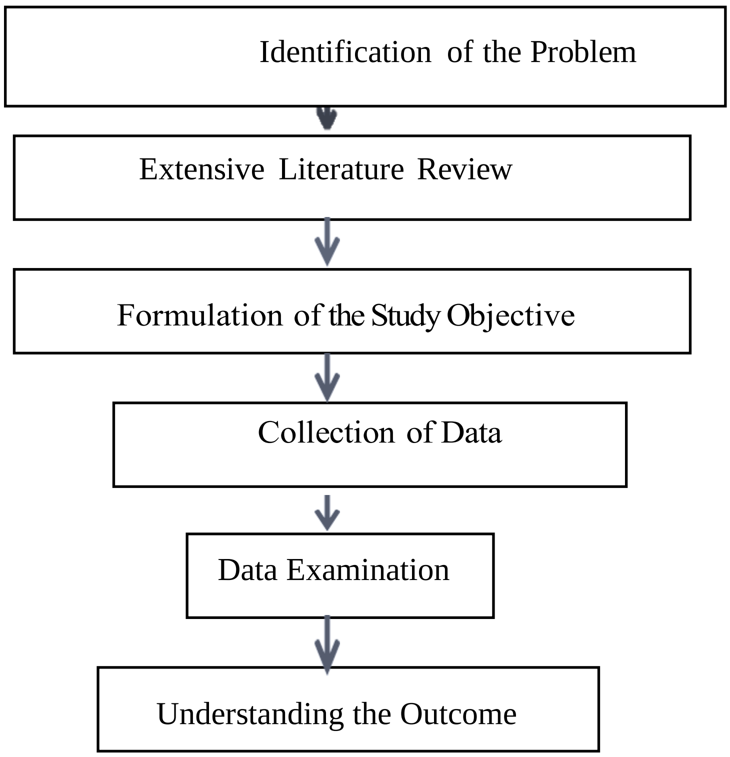

Figure 3. 2. Framework of the study

3.6. Types and sources of data

Data was collected and organized from both primary and secondary sources. Primary data was gathered using a semi-structured questionnaire given to smallholder farmers, cooperative unions, extension specialists, and mechanization service providers. Secondary data was sourced from the agriculture office in the West Arsi zone, which includes the Shashemene, Arsi Negele, and Siraro woredas, as well as from published books, academic journals, reports, manuals, unpublished documents, websites, policy papers, and other relevant materials. The data collected included both quantitative aspects (shown in numerical values and percentages) and qualitative aspects (which describe quality indicators like good, fair, poor, sufficient, and insufficient).

3.7. Method of data collection

A structured questionnaire was created to collect important information from the households interviewed, to obtain both qualitative and quantitative data. Three enumerators were chosen based on their educational qualifications, recommendations from the Woreda Office of Agriculture, and their experience with the local farming community. They were informed about the study's objectives, the importance of gathering information from individual respondents, and the procedures in place to ensure anonymity and confidentiality during the interviews. Additionally, they were advised to handle data collection carefully and approach interviewees with respect.

3.7.1. Farm survey

In 2024, 150 households comprising 126 smallholder farmers and 24 stakeholders were interviewed across various locations to assess the effectiveness of agricultural mechanization services. The focus was on how well these services meet the needs of farmers and their impact on productivity and profitability. The evaluation examined several factors, including the availability and cost of equipment, the quality of service, and the overall outcomes for farmers. Questionnaires were distributed only after obtaining explicit consent. Households were selected using a systematic sampling method in the study villages, following representative transect routes. Every other model farmer was chosen from alternating sides of the track. If a selected household was unavailable, the next household was chosen instead.

3.7.2. Focus group discussion

A parallel focus group discussion (FGD) on the effectiveness of agricultural mechanization services will examine how well these services meet the needs of farmers. It will evaluate the effectiveness of the services, identify areas for improvement, and address the challenges faced by both farmers and service providers concerning agricultural machinery and mechanization. Furthermore, the discussion will generate ideas for enhancing service delivery and expanding the range of mechanization services offered, such as tractor rentals, combine harvesters, plowing, and planting. Irrigation and other machinery-related services will be provided through focus group discussions (FGDs). These discussions will consist of small groups of informed households meeting at locations that they have chosen and agreed upon.

3.7.3. Interviews

Research on agricultural mechanization in Ethiopia is relatively limited. Consequently, quantitative data on various types of machinery were collected from scarce secondary sources and cross-verified with insights from farmers, importers, dealers, and manufacturers. A checklist was developed to facilitate interviews with diverse stakeholders, addressing all aspects of the subsector. One-on-one interviews, key informant discussions, and focus group sessions were utilized to gain a deeper understanding of the sector in alignment with the study's primary objectives.

Primary data was gathered from chosen respondents using organized questionnaires, while secondary data was sourced from the Internet, government offices, and literature by reviewing documents in the study areas.

The questions are directed at the acceptance and awareness of agricultural mechanization services. This included an examination of the types of mechanization technology, the effectiveness of these services, access to and availability of technology, as well as the adoption, affordability, and impact of technology on productivity in the region.

3.8. Data Collection, Sample Size, and Techniques

Sample farmers from the woreda were chosen using both purposive and random sampling methods. A multistage sampling technique combined these two approaches. Three kebeles were chosen in Shashemene, while two kebeles were selected from both Arsi Negele and Siraro. Data was collected on the farm owners, including information on mechanization services, age, farm size, education, and years of farming experience.

3.8.1. Justification for the selection of the woredas

The selection of the three woredas, Shashemene, Arsi Negele, and Siraro, from the twelve districts in the West Arsi Zone was based on purposive sampling, with the intent of targeting areas most relevant to the study of agricultural mechanization service utilization. These districts were specifically chosen because they exhibited relatively higher levels of mechanization adoption, particularly in operations such as ploughing, harvesting, and threshing. Farmers in these areas had notable exposure to various mechanization models, including private rental services and cooperative-led provision.

Additionally, these woredas were known for their high agricultural potential, being major producers of key cereal crops like wheat, maize, barley, and teff. The scale of production in these areas made them ideal for evaluating the effectiveness and impact of mechanization on productivity. Another critical factor was the availability of mechanization service providers, including private individuals, cooperatives, and organized youth groups, alongside the presence of machinery rental centers and service cooperatives.

The selected woredas have also been prioritized in various development initiatives aimed at promoting agricultural mechanization. Furthermore, these districts reflect diverse agro-ecological conditions, with variations in altitude, soil type, and rainfall, which enhances the generalizability of the findings across other similar regions.

Their accessibility and infrastructure also supported their selection; better road networks and transport systems allowed easier movement of machinery and enabled the research team to conduct fieldwork effectively. These areas were characterized by active farming communities, with a dense population of smallholder farmers engaged in both traditional and semi-mechanized agriculture. The presence of organized farmer groups also facilitated smooth data collection. Overall, the woredas offered a balanced and representative setting for the study, capturing both mechanization adopters and non-adopters, a variety of service models, and geographic diversity within the West Arsi Zone.

Table 3. 1. Sample sites and machinery owners covered in the study area

Woredas	Machinery owners	Sampled selected kebeles
Shashemene	Farmers, assemblers, importers, cooperatives, service providers, etc.	Idola Burka, Alache Erebete and Awasho kebele
Arsi Negele		Ali Woyo and Gorbi Derera
Siraro		Fande Ejersa, Lencha lama

3.8.2. Rational selection of the respondents

Based on the study areas mentioned below, Slovin's formula was used to find the right number of respondents. This calculation took into account the total estimated population of 763,883 across three woredas, with a 5% margin of error (0.05) and a Z-value of 1.96, which relates to a 95% confidence level. Consequently, the sample size was estimated to be around 400. From this sample, 150 respondents were chosen for the study, comprising 126 smallholder farmers and 24 stakeholders or experts. The household sampling was conducted across seven kebeles within three woredas: Arsi Negele, Shashemene, and Siraro districts. Specifically, 25 farmers were selected from Ali Wayo and 24 from Gorbi Derera in Arsi Negele; 14 from Idola Burka, 13 from Alache Erebete, and 13 from Awasho in Shashemene; and 19 from Fande Ejersa and 18 from Lencha Lama in Siraro. Within each kebele, smallholder farmers were selected using simple random sampling to ensure fair representation. Stakeholders and experts were selected purposively based on their roles in agricultural mechanization service utilization and rural development. This sampling approach balanced randomness, representation, and expert insight across the study area. The sample size was determined using the formula from Slovin and Mamani (1960), which is useful for calculating sample size when there is limited information about the population, as follows:

$$n = \frac{N}{1 + N(e)^2} ------------------------- \text{equation (3.1)}$$

3.8.2.1. The selection characteristics of the respondent

The selection of 126 smallholder farmers and 24 stakeholders for this study was conducted using a simple random sampling technique to ensure fair and unbiased representation throughout the study area. Sampling took place within seven kebeles distributed across three woredas in the West Arsi Zone.

To be eligible, respondents needed to be resident smallholder farmers within these kebeles and actively engaged in farming, typically operating at a subsistence or semi-commercial level. A key selection requirement was that the farmers had to have experience with or exposure to agricultural mechanization services, such as tractor hiring for plowing, the use of combine harvesters, mechanized threshing or sowing, and mechanized grain transport. All selected farmers were also required to have been actively farming during the most recent production season to ensure the relevance of their input and feedback.

In addition to meeting the core criteria, efforts were made to ensure diversity in landholding size, farming scale, access to mechanization services, and socio-demographic characteristics such as education, age, and gender, allowing for a representative cross-section of the farming population. Finally, informed consent and willingness to participate in structured interviews were essential for inclusion in the study. This comprehensive approach aimed to provide a well-rounded and contextually accurate understanding of mechanization service utilization among smallholder farmers in the study area. Therefore, the sample size distribution in a target study area is shown as follows:

Table 3. 2. Sample size distribution in targeted areas

Woreda	Sampled Kebele	Sampled Household Size		Total Number of Households Sampled
		Farmers	Stakeholders	
Arsi Negele	Ali Wayo, Gorbi Derera	49	8	57
Shashemene	Idola Burka, Alache Erebete, Awasho	40	9	49
Siraro	Fande Ejersa, Lencha Lama	37	7	44
Total	—	126	24	150

3.8.3. Sampling technique

Respondents were selected to ensure a comprehensive understanding and capture diverse perspectives. The study employed a staged purposive sampling approach. Primary sampling units were selected from districts in the West Arsi Zone where agricultural mechanization technologies, such as tractors and combine harvesters, are widely used. Three woredas (Shashemene, Arsi Negele, and Siraro) were intentionally chosen due to their adoption of mechanized farming practices.

Respondents included stakeholders from agriculture, research institutions, development partners, and both small and large machinery enterprises. Within each woreda, specific kebeles and cooperative farms were selected, and local experts facilitated focus group discussions. Although some bias was observed (as farmers associated the study with potential credit support), this was mitigated through clarification of the study’s objectives. The interviews were conducted using semi-structured questionnaires, tailored to match each participant’s background and knowledge level.

3.8.4. Methods for creating instruments

The questionnaires and interview questions were created in English. After that, these questions and checklists were translated into local languages (Afan Oromo) for informants who want to answer in Afan Oromo.

3.9. Methods of data analysis

Both quantitative and qualitative primary and secondary data were gathered, processed, and analyzed using tables, figures, and graphs. The data analysis, result interpretation, and research findings reporting were performed with SPSS version 27 software. Descriptive statistics like mean, median, standard error, frequency, and percentage were used to describe the respondents and their results. The analyzed data were displayed in different formats, including tables, pie charts, bar graphs, and regression graphs. This approach enabled a comprehensive description and analysis of the characteristics of smallholder farmers, including their farming activities and related aspects within the sample group.

3.10. Analytical model to evaluate the agricultural mechanization service

The linear regression model was employed to identify the key factors influencing agricultural mechanization services in the study area. This model aims to evaluate how the utilization of mechanization services impacts the region.

The study found twelve key factors: access to farming machinery, availability of spare parts, types of machinery in use, level of mechanization technology, cluster farming, age of the household head, education level, size of the farm, family size, distance to the farm, and farming experience.

This model was chosen because the dependent variable is continuous, which is suitable for determining a cause-and-effect relationship among these factors. To calculate the multiple linear regression function, Y is the dependent variable that reflects the mechanization service, which relies on ten independent variables. The model includes both continuous and categorical (or dummy) variables. The general format of multiple linear regression models can be outlined as follows:

$$\mathrm{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \epsilon_0 ------------------- \text{equation (3.2)}$$

Y = Agricultural mechanization service utilization (dependent variable)

$\beta 0$ = Intercept term (constant), and $\beta 1$, $\beta 2$, ..., $\beta 12$ = Coefficients of the independent variables, showing the impact of each factor on agricultural mechanization service utilization

$\varepsilon 0$ = Error term (residuals), representing unobserved factors affecting the model

X_3, X_5, X_6, X_8, X_9 Continuous and dichotomous input variables determine dependent X_1, X_2, X_4, X_7, X_{10}, X_{11}, X_{12} variables, respectively

X_1 = Accessibility of farmers to agricultural machinery (0 = not accessible, 1 = accessible)

X_2 = Farmers' access to cluster farming (0 = not accessible, 1 = accessible)

X_3 = Age of the household head (in years)

X_4 = Farmers' education level (0 = illiterate, 1 = educated)

X_5 = Farm size (in hectares; the number of hectares the farmer owns)

X_6 = Family size (number of family members in the household)

X_7 = Availability of spare parts for machinery (0 = not accessible, 1 = accessible)

X_8 = Farm distance to access service (km)

X_9 = Farm experience (years)

X_{10} = Types of machinery used (1= tractor, 2= combiner harvester, 3 =other)

X_{11} = Level of mechanization technology (0 = low, 1 = medium, 2= high)

X_{12} = Quality of service (0 = not accessible, 1 = accessible)

ε_0 = Model error terms (residuals)

3.10.1. Definition of linear regression model specification variables

Accessibility of farmers to agricultural machinery (X_1): Access to mechanization services significantly impacts the productivity and profitability of smallholder farmers. Unfortunately, many of these farmers face challenges such as high costs, limited availability, and inadequate service quality. To address this issue, it is essential to evaluate and analyze the hours of mechanization services accessible to farmers. This assessment will help identify gaps and opportunities for improving the delivery and adoption of mechanization services among smallholder farmers.

Access to cluster farming for farmers (X_2): The government supplies farming resources to farmers working in groups. This assistance helps them use farm equipment and suitable resources efficiently. When farming inputs are improved and mechanized services are used, productivity is likely to rise. Thus, it is believed that being part of cluster farming will positively and significantly affect crop yields.

Age of household head (X_3): The age of farmers is likely to affect how well they understand the benefits of farm machinery. Typically, older farmers have a better grasp of these advantages. On the other hand, younger farmers might have more access to modern farming methods because of their better education, which makes them more knowledgeable about new technologies. In comparison, older farmers might not have the same access to this information. Thus, it is suggested that younger farmers could have a more positive impact on crop production.

Farmer's education level (X_4): Formal education improves a farmer's skills in seeing, understanding, and reacting to modern farming methods. Thus, it was suggested that literate farmers are more inclined to use farm equipment and produce greater yields per hectare than those who are illiterate. Education was classified as either illiterate or educated.

Farm size (X_5): Having a large piece of land can help build wealth. Families with big landholdings can produce more crops using machines. As a result, it is believed that farmers with larger farms are more positive about using machines and see a bigger effect on crop production than those with smaller farms.

Family size (X_6): A bigger family means more hands to help on the farm. As a result, farmers with larger families tend to use more manual labor instead of machines. Thus, it is suggested that smaller families are more likely to use machinery, which can improve production compared to larger families.

Availability of spare parts (X_7): The availability of spare parts for mechanization technology is a critical factor in agricultural development in West Arsi, Ethiopia. However, the current situation is marked by a low supply, high costs, and poor quality of spare parts. These issues negatively impact the performance and maintenance of machinery, thereby diminishing the benefits of mechanization for farmers. Consequently, it is essential to enhance the spare parts supply chain and ensure the availability of affordable and reliable spare parts in the West Arsi zone.

Farm distance to access services (X_8): Farmers with plots located near the main road or town are more likely to utilize mechanization machinery related to those whose plots are situated farther away. According to Deresse et al. (2018), the likelihood of adopting improved agricultural technologies decreases for farmers who travel from greater distances.

It is believed that farms or plots close to the main road or town have a greater and more positive effect on crop production compared to those in distant areas.

Farm experience (X_9): This variable tracks how many years a farmer has been farming. Farmers with more experience are likely to know peak operational times better. According to Mohammed Ismael (2024), household heads with substantial farming experience demonstrate higher productivity. It is believed that household heads with more experience will positively and significantly affect crop production.

Types of machinery used (X_{10}): The types of machinery used in West Arsi, Ethiopia, include tractors and combine harvesters, which can cut, thresh, and clean cereal crops in a single operation. These machines are particularly beneficial for wheat production in the study area. In recent years, combine harvesters have gained popularity due to the increasing demand for mechanization services, higher rural wages, and the necessity of completing harvests promptly. However, the availability and affordability of these machines remain limited for many smallholder farmers, who primarily depend on animal or manual labor for most of their agricultural activities.

Level of mechanization technology (X_{11}): The level of mechanization technology in West Arsi, Ethiopia, remains low compared to other regions and countries. Most farmers depend on animal traction and hand tools for land preparation, planting, weeding, and harvesting. However, recent years have seen some progress in introducing tractor-based machinery, particularly for wheat production. Additionally, the government has developed a national mechanization strategy aimed at increasing the availability and affordability of agricultural machinery for smallholder farmers.

Quality of service (X_{12}): It is a crucial factor for the success of mechanization technology in agricultural development. In West Arsi, Ethiopia, the quality of service (QoS) is influenced by various factors, including the availability, affordability, accessibility, reliability, and suitability of mechanization services. This thesis aims to assess the current status and challenges of QoS in West Arsi, Ethiopia, and to provide recommendations for its improvement.

3.10.2. Dependent variables evaluate the effectiveness of AMS

The dependent variable is measured or observed during a study. To evaluate Agricultural Mechanization Services, it affects AMS in various aspects of agricultural production.

Mechanization adoption rate (R): Measures the proportion of farm households that have adopted mechanized practices, utilization, and acceptance of AMS among farmers to reflect the accessibility, affordability, and relevance of mechanization services.

$$\mathrm{R} = \left(\frac{\text{Number Of Farm Households Using Mechanized Services}}{\text{Total Farm Household Survey}}\right) \text{x}100 - - - - - - - - \text{equation (3.3)}$$

Cropping intensity index (CI): Measures how many times a unit area of land is cropped in a year due to timely and efficient operations enabled by mechanization. A higher confidence interval (CI) reflects better land use and increased productivity facilitated by AMS.

$$\mathrm{CI} = \frac{\text{Total Cropped Area}}{\text{Net Sown Area}} - \text{equation (3.4)}$$

Average yield gain (GY): shows the difference in average crop yield between farmers who use AMS and those who don't. Indicates productivity improvement directly attributable to mechanization.

$$GY = \text{Mean yield of adopters} - \text{Mean yield of non-adopters} - - - - - \text{equation (3.5)}$$

Field efficiency (FE): -Ratio of actual productive working time to total time spent (including idle time) during machine operation.

$$\mathrm{FE} = \left(\frac{\mathrm{TP}}{(\mathrm{TP}+\mathrm{Idletime})}\right) \text{x}100 - \text{equation (3.6)}$$

Capacity utilization (CU): Measures how much of the machine's rated (maximum) capacity is used in the field. Indicates efficiency and scale of use of available machinery. The ratio of the total area covered or actual output to rated capacity.

$$\mathrm{CU} = \left(\frac{\text{Actual out put}}{\text{rated capacity}}\right) \text{x}100 - \text{equation (3.7)}$$

Field capacity (FC): Area covered per hour of actual productive time by a machine. Helps measure the speed and effectiveness of mechanized operations.

$$\mathrm{Fc} = \frac{\mathrm{A}}{\mathrm{TP}} - \text{equation (3.8)}$$

Field work rate (FWR): - Total area covered per total time spent. Provides a realistic view of the actual performance of mechanized operations in the field.

$$\mathrm{FWR} = \frac{\mathrm{A}}{\mathrm{TP}} - \text{equation (3.9)}$$

CHAPTER FOUR

RESULT AND DISCUSSION

4.1. Introduction

This chapter presents the findings related to the study's goals. The objectives included assessing the current status of agricultural mechanization technology, investigating how differences in mechanization services impact the production and productivity of smallholder farmers, analyzing the effects of training limitations on these farmers' adoption of agricultural technology, and offering recommendations for effective service delivery in the West Arsi zone, particularly in the Shashemene, Arsi Negele, and Siraro districts. The study also seeks to examine how the availability of agricultural mechanization services affects technology adoption among smallholder farmers in these regions, as well as how the demographic traits of farmers influence the use of agricultural mechanization services.

4.2. Demographic and socioeconomic characteristics of smallholder farmers

The demographic and socioeconomic traits of households surveyed in the Shashemene, Arsi Negele, and Siraro districts across seven kebeles were analysed. The interviews aimed to gather information on various factors such as age, gender, education level, marital status, household leadership, family size, access to agricultural technology, cluster farming, distance to farms, income sources, and labor activities. These characteristics are crucial for understanding the varied backgrounds of the respondents and their influence on mechanization services and socioeconomic factors.

4.2.1. Age of farmers

Table 4.1 presents the research aimed at identifying the age groups of the main respondents in the Shashemene, Arsi Negele, and Siraro districts by requesting them to provide their age ranges. This information was intended to assess the age distribution among the respondents.

Table 4. 1. Age distribution of respondents

Age distribution in years	Frequency	Percent (%)
Below 35 years	46	36.5
35-50 years	49	38.9
Above 50 years	31	24.6

Source: Field survey data (2016/17).

This study included 126 heads of smallholder farming households and 24 agricultural experts. According to Table 4.1, the majority of respondents were aged between 35 and 50, making up 38.9% of the total. This suggests that most respondents are in their prime working years, which could positively influence agricultural mechanization services and crop production. The number of respondents declined for those over 50, indicating that older farmers may be less likely to continue farming due to the physical demands of the work as they age.

4.2.2. Household head

Table 4.2 showed that 80.2% of households were headed by males, significantly more than those headed by females. Traditionally, women tend to focus on indoor tasks, while men are more involved in outdoor activities such as farming. As a result, male-headed households are more likely to be mobile and participate in various meetings, giving them greater access to new technologies compared to female-headed households.

Table 4. 2. Household head of respondents

Variables	Categories	Frequency	Percent
Household Head	Female	25	19.8
	Male	101	80.2

Source: Field survey data (2016/17).

According to Abdisa & Mehare (2023), research indicated that households led by women were less likely to manage economic resources and the type of economic activities they engaged in. In contrast, households led by men were more inclined to own, use, or manage machinery, irrigation pumps, and harvesters compared to those led by women. This disparity may stem from women's lower awareness of the benefits of mechanization.

4.2.3. Household Size

The size of a smallholder farmer's household is an important factor that affects farm mechanization services. A bigger family means there is more labor available from family members for farming tasks.

Table 4. 3. Household size of respondent

Variables	Categories	Frequency	Percent
Household Size	No Child	6	4.8
	Below 3	24	19.0
	(4-6)	56	44.4
	Above 7	40	31.7

Table 4.3 indicates that 19% of households had fewer than three members, whereas 76.1% had four or more. This suggests that larger households are more likely to use farmland more intensively and perform essential farming tasks promptly compared to smaller households, which may have fewer labor resources. Consequently, this could reduce the likelihood of farmers relying on farm machinery.

4.2.4. Marital status of respondent

In a family context, husbands and wives assume complementary roles in their economic activities. As shown in Table 4.4, a significant majority of the participants were married (94.4%), while those who were unmarried constituted a small minority (4.8%) and were generally younger. This situation suggests that households with both a husband and a wife are more advantageous than single-headed households, as they can more effectively share responsibilities and tasks on the farm, potentially resulting in greater specialization and enhanced agricultural output.

Table 4. 4.The marital status of the respondent

Variables	Categories	Frequency	Percent
	Single	6	4.8
Marital Status	Married	119	94.4
	Divorcee	1	0.8

Source: Field survey data (2016/17).

4.2.5. Family source of income in the study area

Out of all the respondents, 88.9% of the farmers were involved in agriculture, while just 11.1% were involved in other types of businesses. Conversely, 75.4% were engaged in crop production, and 13.5% were involved in mixed farming, which includes both crops and animal production.

Table 4. 5. Source of income activity in the study area

Variables	Categories	Frequency	Percent
	Crop Production	95	75.4
Source of Income	Mixed Farming	17	13.5
	Other Business	14	11.11

Source: Field survey data (2016/17).

According to Zerssaetal (2021), in Ethiopia, smallholder farming was mainly mixed farming. However, this study showed that most respondents in the study areas focused more on crop production than on mixed farming.

4.2.6. Educational level

The research aimed to determine the formal educational qualifications of participants from Shashamene, Arsi Negel, and Siraro District. Households were requested to indicate their levels of formal education.

Table 4. 6. The educational level of the respondents

Variables	Categories	Frequency	Percent
Education Head (Grade)	Illiterate	71	56.3
	Read and write	19	15.1
	Formal Education	20	15.9
	College/University	16	12.7

Source: Field survey data (2016/17)

Education significantly influences the views of smallholder farmers regarding the adoption of farm mechanization. Younger and more educated farmers tend to be more receptive to new concepts and innovations. Among the 126 participants surveyed, approximately 56.3% were illiterate, while 15.1% had acquired reading and writing skills through informal education or were considered literate. As depicted in Figure 4.1, around 15.9% had received formal education, and 12.7% had attended college or university. In total, 43.7% of the farmers had some level of schooling. Consequently, a majority of farmers lack literacy skills, which limits their awareness of farm mechanization and hinders their ability to optimize production.

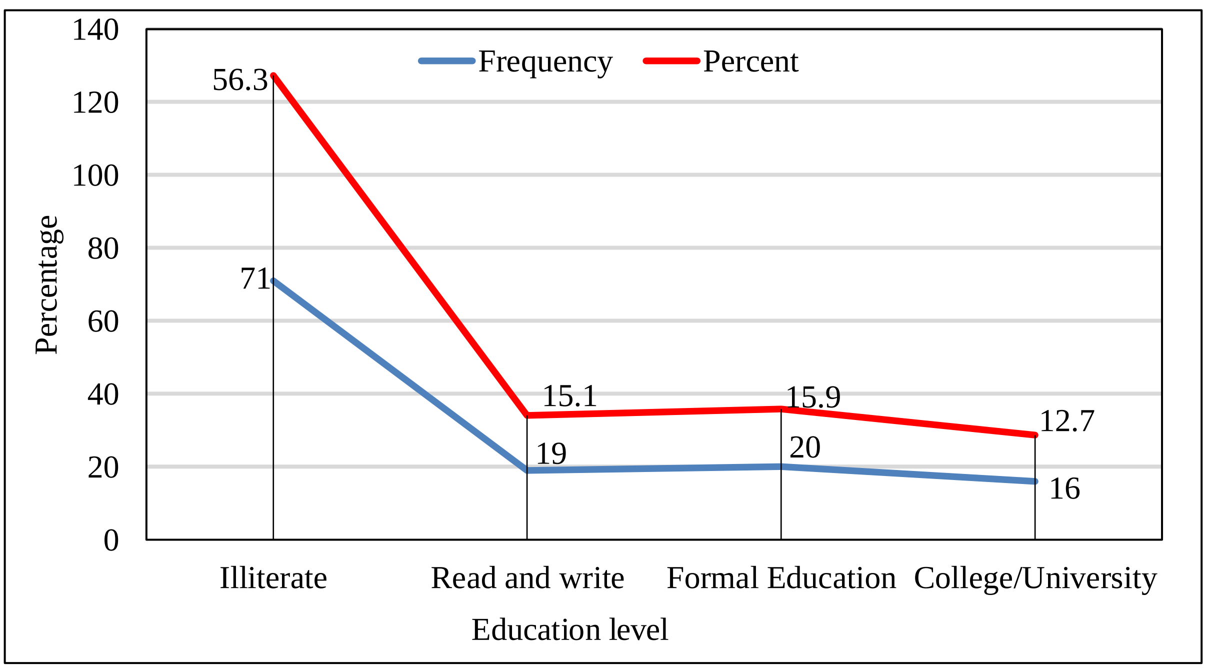

Figure 4. 1. Distribution of respondents according to their level of education

A significant issue hindering agricultural productivity is illiteracy. This challenge has consistently impeded both agricultural development and overall productivity over the years. Farmers with lower levels of education are less inclined to embrace mechanization technologies than their more educated counterparts, as noted in their findings. This research corroborated these observations, indicating that the adoption of agricultural machinery rises in correlation with educational attainment.

4.2.7. Farming work experience

The research aimed to explore the experiences of the respondents, specifically focusing on the duration of their professional engagement. This approach was intended to assess the extent of their exposure to various factors that affect the adoption of agricultural technology among smallholder farmers. The findings are presented in Table 4.7.

Table 4. 7. Working experience of the respondents

Years	Frequency	Percent %
1-10 years	19	15.07
11-25 years	48	38.1
Above 25 years	59	46.83
Total	126	100.0

Source: Field survey data (2016/17)

Farmers with more experience in farming are expected to possess better skills and knowledge, as experienced farmers engage more with farming compared to those who are less experienced.

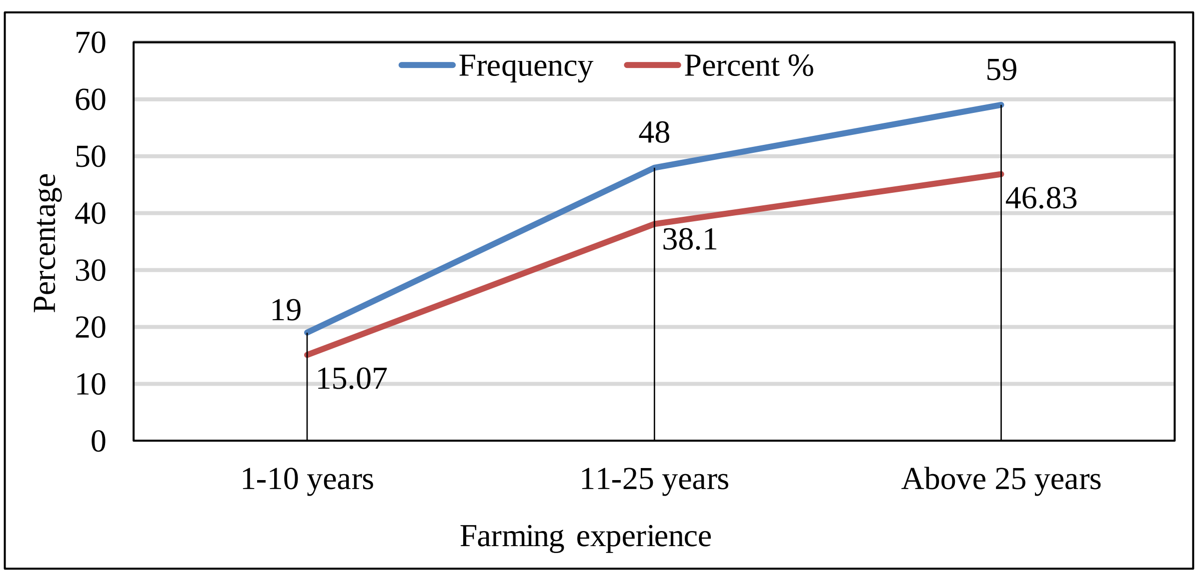

Figure 4. 2. Farmer's farming experience in the study area

The study area exhibited a diverse range of farming experience, spanning from 1 to 50 years. Farming experience was categorized into three groups based on the duration of agricultural work. As shown in Figure 4.2, 46.8% of the participants had over 25 years of farming experience. Approximately 15.1% of the farmers had between 1 and 10 years of experience, while 38.1% fell within the 11 to 25 years range. Consequently, a significant majority of farmers (75%) in the area possess extensive farming experience. This extensive experience leads most farmers (75%) to prefer mechanization over traditional farming methods. Additionally, smallholder farmers often lack the resources to invest in large farming machinery. As a result, those with long-term farming experience tend to produce less and earn lower incomes in the study area.

4.2.8. Availability of labor activity in the study area

Labour availability plays a vital role in the agricultural industry, impacting productivity, efficiency, and the economic growth of rural regions. The presence of both skilled and unskilled workers significantly influences the pace and quality of agricultural operations, ranging from planting to harvesting. For policymakers, farmers, and agricultural planners, comprehending labour availability is crucial, as it directly influences the execution of farming methods and the sustainability of agricultural output.

This research seeks to evaluate labour availability within the designated area, focusing on the mean and standard deviation to understand the variability and reliability of the available workforce.

Table 4. 8. Labour availability in the study area

Variable	Mean	Standard Deviation
Labor availability	4.23	1.36

4.3. Landholding, use, and characteristics

According to figure 4.3, Land serves as a crucial resource for smallholder farmers, with ownership being essential for their survival. The extent of landholding significantly influences the degree of agricultural mechanization, which is vital for these farmers. The research indicated that a majority of participants in the study area owned their land; however, the size of landholdings varied considerably among households. In addition to their owned land, which constitutes the largest share of their total cultivated area, small-scale farmers also engage in land

-sharing and renting practices. Some farmers opt to lease out or share portions of their land for various reasons.

Table 4.9, 51.59% of farmers in the study area possess land ranging from 1 to 2.5 hectares. Additionally, 24.6% of farmers own land between 2.6 and 6 hectares in the West Arsi zone, specifically in the districts of Shashamene, Arsi Negele, and Siraro. Overall, the predominant landholding among farmers in the study area is less than three hectares.

Table 4. 9**.** Land holding use characteristics in the study area

Land size (ha)	Frequency	Percent
0.00 - 0.25	8	6.35
0.26 - 0.99	22	17.6
1 - 2.5	65	51.59
2.6 – 6 and above	31	24.6

Table 4.10 presents a summary of landholding sizes per household categorized within the study area. The data indicates that 1.08% of respondents possess land holdings ranging from 0.00 to 0.25 hectares, whereas 61.83% own between 1 and 2.5 hectares.

Table 4. 10**.** Land area falls within different altitude zones in the study area

Land size (ha)	High altitude (%)	Mid-altitude (%)	Average (%)
0.00 - 0.25	2.15	0.00	1.08
0.26 - 0.99	16.13	7.02	11.57
1 - 2.5	56.99	66.67	61.83
2.6 – 6	24.73	26.32	25.52

Source: Field survey data (2016/17)

Table 4.11 presents a summary of the sources of land and the perspectives of farmers regarding the trend in land holding size per household. The findings indicate a decline in land holding size per household, accounting for 93.55%, while a constant size is observed in 6.47% of cases. The predominant source of land is inheritance from parents, comprising 61.09%, inherited from parents by land distribution, which represents 33.25%.

Table 4. 11**.** Source of land in the study area

Variables	Parameters	High altitude (%)	Mid-altitude (%)	Average (%)
Source of land	Land Distribution	41.94	24.56	33.25
	Inherited from Parents	53.76	68.42	61.09
	Shared from Relatives	4.30	7.02	5.66
Landholding trend	Decreasing	93.55	92.98	93.27
	No Change	6.45	7.02	6.73

Source: Field survey data (2016/17

4.4.Cluster farming in the study area

Cluster farming enables farmers to adopt complete solutions for growing crops, which include choosing and preparing land, using inputs effectively, protecting crops, and connecting to markets. This is made possible through strong extension services, better training opportunities, easier market access, increased collaboration, and organization. Approximately 57.94% of smallholder farmers took part in cluster farming, which provided access to machinery and inputs, government support, moderate land size, and more adoption of agricultural mechanization technology to improve productivity by facilitating resource sharing and enhancing service delivery.

Table 4. 12**.** Farmers organized cluster farming in the study area.

Cluster Farming Variables	Frequency		Percent (%)
Organized in cluster farming	Yes	73	57.94
	No	53	42.06

The percentage of farmers involved in cluster farming was significantly higher than those who were not (see Table 4.12). Farmers in cluster farming enjoyed better access to farm machinery and received regular support from the government and professionals, which allowed them to benefit from more agricultural technologies compared to their unorganized counterparts, leading to increased productivity. Smallholder farmers engaged in cluster farming also had improved access to machinery, better seeds, and fertilizers. According to Hussein & Geleta (2021) reported that they also collaborate and exchange information, work together in a team to help them view issues from various angles, which individual farmers cannot achieve.

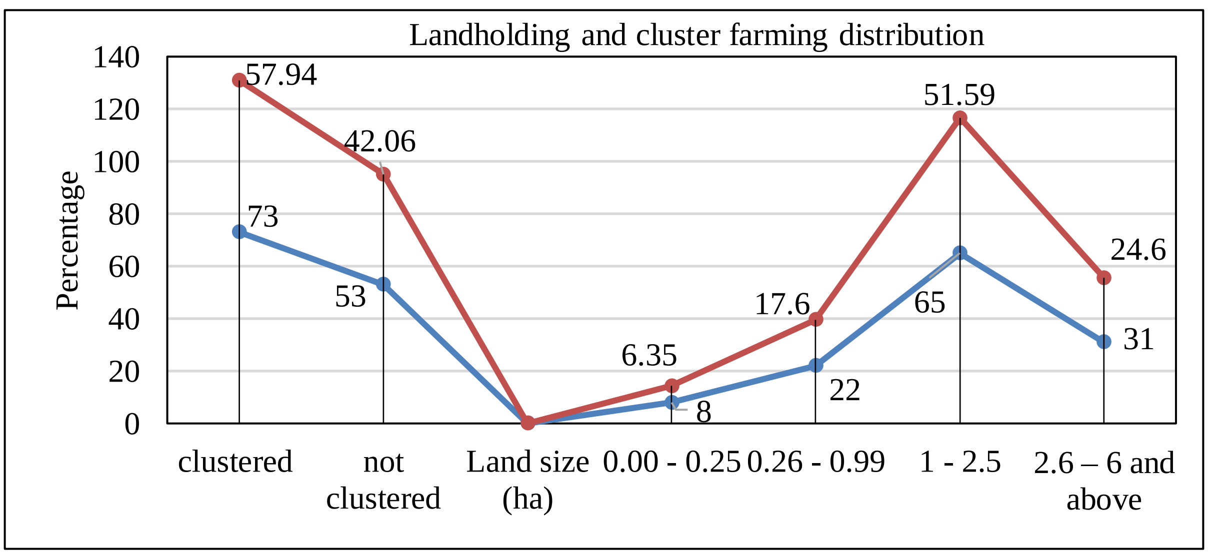

Figure 4. 3. Landholding and cluster farming practices

4.5. Patterns of production for major crops cultivated

4.5.1. The landscape of farmland

The farmland in the West Arsi Zone of the Oromia Region, especially near Shashamene, Arsi Negele, and Siraro, showcases a variety of agricultural features. This area, situated in central Ethiopia, has distinct topography, climate, and soil types that shape its farming methods. The physical characteristics of the landscape play a significant role in determining cropping patterns, productivity, and farming suitability. Table 4.13, 92.07% of the sampled land consists of flat fields, while 7.93% is hilly or uneven. These factors make the region well-suited for mechanized farming, highlighting the appropriateness of the selected district for such practices.

Table 4. 13**.** Distribution of landscape in the study area

Landscape	Frequency	Percent %
Plain field	116	92.07
Sloppy field	10	7.93

4.5.2. Major crops grown

Table 4.14 displays the primary crops cultivated in the study area. Identifying these key crops helps in calculating the mechanization index and associated production traits. At the overall level, the average yield for the top five crops, wheat, Teff, maize, and sorghum, is presented.

Table 4. 14**.** Mechanization operation methods on major crops grown

Crop Type	Fr	%	Tractor Plough (%)	Harrow & Levell (%)	Planting (%)	Combine Harvest (%)	Threshes (%)	Sheller (%)	Transport (%)	Storage (%)
Wheat	44	34.92	22.99	4.85	5.6	41.24	7.45	0	23.72	2.92
Teff	38	30.20	6.88	0	0.46	0	0.92	0	0.46	0.46
Maize	25	19.84	6.75	0	0	0	0	23.63	1.26	0.42
Sorghum	19	15.08	8.48	0	0	0	0	0	1.12	3.37

Source: - Field survey data- 2016/17, Sample size =126, Fr. - Frequency; % - Percent

Mechanical power plays a crucial role in farming operations for major crops. According to Figure 4.4, tractor plowing is most prevalent for wheat, accounting for 23%. The data also indicates that mechanical harvesting is predominantly used for wheat, representing a significant 41.24%. Additionally, wheat leads to the use of threshers. While some farmers in wheat-growing regions are aware of tractor harrowing and levelling, but this practice is not observed in other cereal crops.

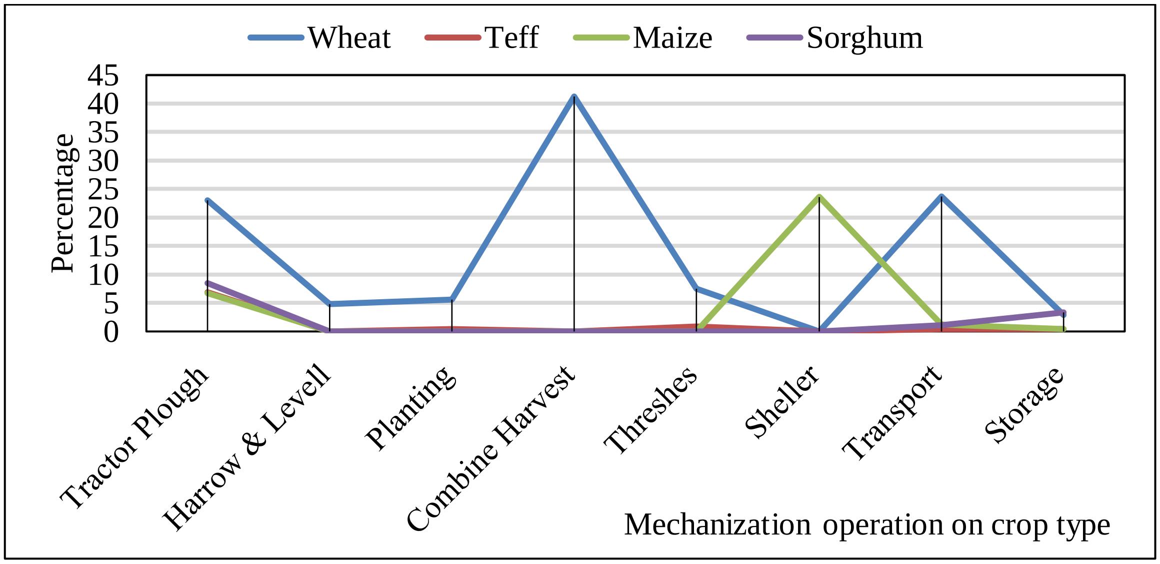

Figure 4. 4. Operation of mechanization by the major crop produced

4.6. Rental-based farm power use for pre- and post-harvest operations

In the study area, numerous farmers rely on renting tractors and farm machinery, such as combine harvesters, from owners of these machines and draught animals during both regular and peak seasons. However, machinery owners tend to prioritize their use during these times. Farmers who rent equipment are charged based on the duration of use, paying higher rates during peak periods and standard rates during regular times.

Figure 4.5 shows the source of power for primary tillage operations (first and second) in the mechanization activities. Farmers commonly utilize a mix of tractor and animal power through rental services. For the first tillage, most farmers (45%) opted for tractors, 29% used draught animals, and 26% employed both methods.

Primary tillage cannot be performed in dry soil conditions until the topsoil softens enough for animal ploughing during the early rainy season, although ploughing depth remains limited when using animals. Similarly, for the second ploughing, most farmers in the area used animal-drawn (42%), while for harrowing with tractors or farm machinery 38%, and for seed covering, it was 16% (as shown in Figures 4.5 and 4.6)

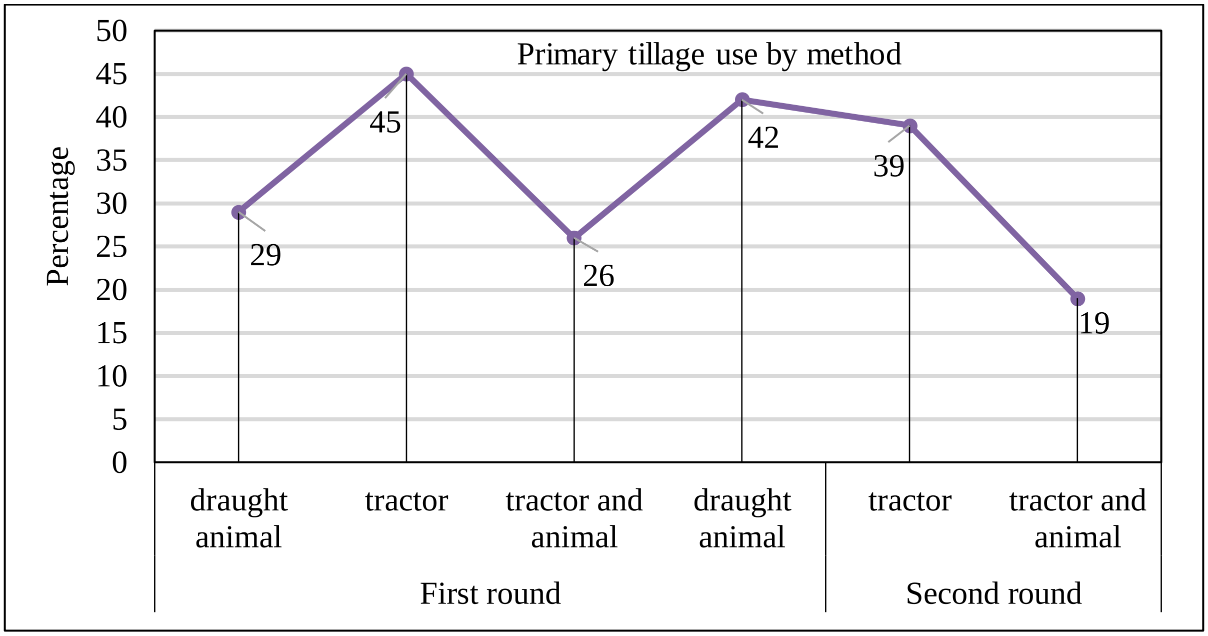

Figure 4. 5. Source of farm power for primary tillage operations

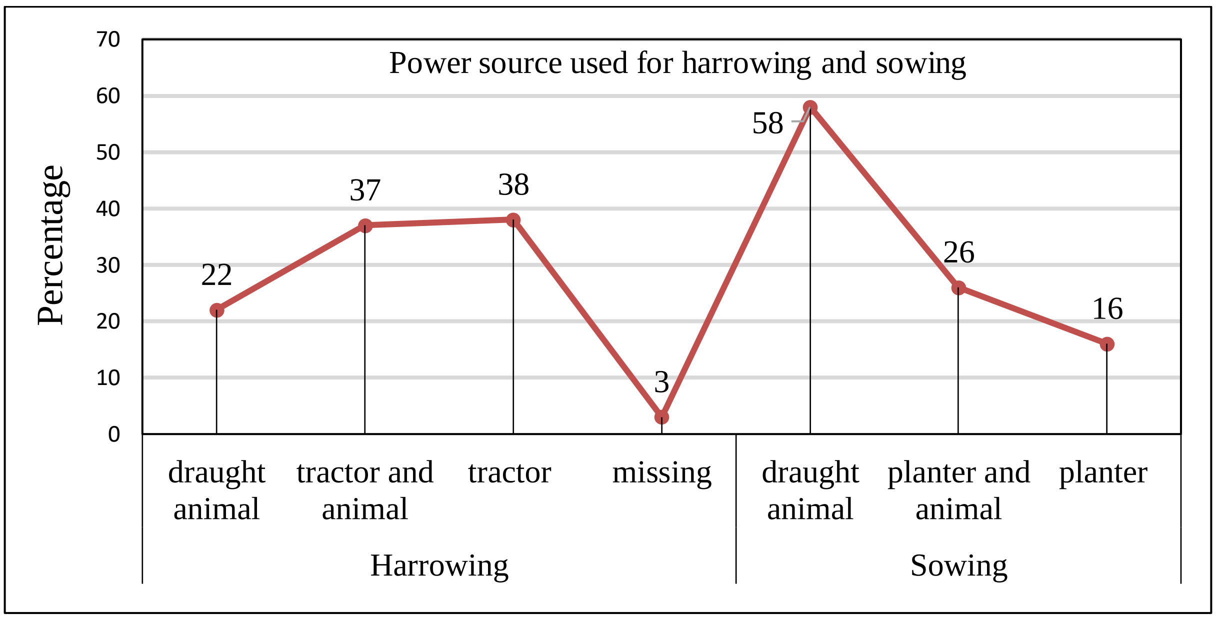

Figure 4. 6. Source of farm power for secondary tillage operations

Farmers in the study area reported that during the dry season, when tractors are used to turn the topsoil, the resulting clods in the inverted layers require additional tractor use for pulverization. This process is crucial for creating an optimal seedbed for crops. In contrast, when draft animals are employed for secondary ploughing on fields that were initially ploughed with tractors, the soil is not adequately pulverized and mixed. As a result, many seeds may become buried beneath clods, negatively impacting crop establishment.

In Figure 4.6, it is shown that 38% of farmers used farm machinery for harrowing operations, while 16% employed machinery for sowing. A small fraction, 3%, chose to skip the harrowing altogether and proceeded directly to the subsequent operations. The decision to engage in harrowing was influenced by the type of crop and the need for effective soil pulverization, reflecting the farmers' understanding of optimal tillage practices. Notably, 16% of smallholder farmers used tractors for seed coverage, indicating a greater awareness of planting techniques involving planters compared to the availability of such equipment in the area.

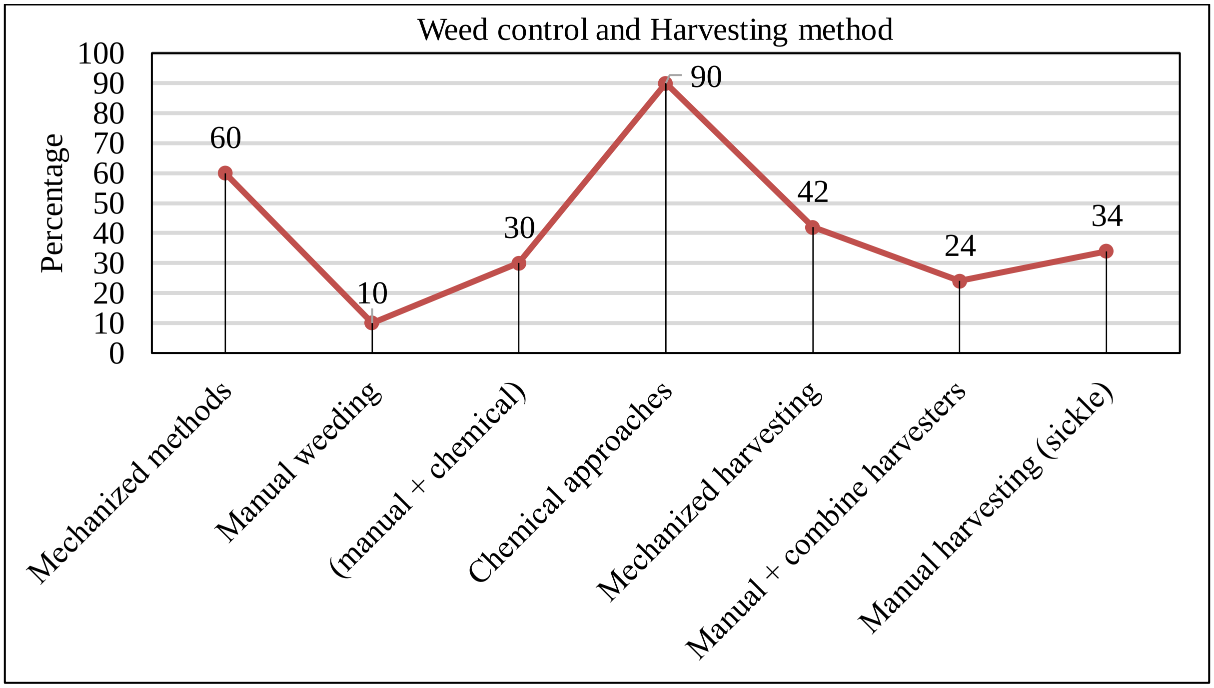

Figure 4. 7. Source of farm power for weed control and harvesting operations

Figure 4.7 illustrates that 60% of farmers in the study area adopted mechanized methods for weed control, while 10% relied on manual weeding, and 30% employed a combination of both manual and chemical methods. Farmers cultivating legumes, such as beans and haricot beans, predominantly used manual weeding methods, while some also resorted to manual methods for cereal crops after applying chemicals to enhance productivity. Overall, 90% of smallholder farmers utilized chemical approaches for weed management. Additionally, 42% of farmers in the area employed mechanized harvesting techniques, 24% used a combination of manual and combine harvesters, and the remaining 34% relied solely on manual harvesting with sickles.

The method of harvesting wheat and teff has improved smallholder farmers' access to combined harvesting techniques. Contributing factors include increased farmer awareness, the introduction of both existing and newly imported combine harvesters, market opportunities, and the suitability of the local topography, all of which have led to higher levels of adoption. Mechanization in the study area has been on the rise, while the number of farmers relying on manual harvesting has steadily decreased. This trend indicates a growing preference among smallholder farmers for mechanized harvesting methods.

The data suggests that farmers' awareness has progressively increased, leading to a significant rise in the adoption of mechanization. Smallholder farmers in the study area show a strong preference for mechanized farming, influenced by factors such as seasonal and weather conditions, ploughing depth, plant residues, timeliness, and the goal of maximizing yield.

4.7. Household grain storage facilities in the study area

The issue of storage represents a significant challenge in Ethiopia, where a considerable portion of post-harvest losses occur. Numerous literature reviews indicate that grain damage in peasant households can be attributed to two primary factors: infestations by weevils and rodents, as well as moisture or the development of moulds. Both of these issues stem from inadequate storage systems. In Ethiopia, post-harvest losses for staple foods vary between 10% and 50%, a notably high figure in a nation where a substantial segment of the population faces food insecurity (Tefera, 2022).

Table 4. 15**.** Grain storage facilities of the households.

Storage type	Frequency	Percent
Keep in a living/animal shelter with a bag	73	57.94
Store in a storage facility with a bag	19	15.1
Utilize contemporary storage "Gotera"	2	1.59
Employ conventional storage "Gotera"	32	25.40

For example, post-harvest losses in maize grain storage throughout 2 to 12 months in the country can range from 11% to 100%, which is quite alarming. The findings of this study indicate that many smallholder households do not store root vegetables such as beetroots, carrots, and potatoes, which are commonly cultivated in the highlands. This lack of storage has led to damage in these root crops, which is further exacerbated by the harvesting methods employed, primarily involving manual digging with traditional tools. Such practices often result in injuries to the crops, making them more vulnerable to spoilage from bacteria and other factors. Overall, inadequate storage facilities and inefficient harvesting techniques significantly contribute to the losses experienced in Ethiopian grain production. For instance, 57.94% of respondents reported storing their crops in simple polyethylene sacks within their homes or in areas designated for livestock, while 25.40% utilized a traditional and insecure storage method known as “gotera.”

4.8. Key constraint affecting mechanization services utilization

Smallholder farmers possess knowledge of various agricultural mechanization alternatives and recognize their advantages, thanks to the support provided by agricultural machinery operators. This assistance enables mechanization service providers to develop the managerial competencies necessary for operating their businesses successfully and facilitating growth (Khandai, 2021).

The government has supported farmers by providing agricultural machinery through both individual farmer groups and cooperative farmer associations. This initiative aims to promote the establishment of agricultural machinery service providers, thereby continuously motivating farmers to enhance the production and productivity of agricultural goods, particularly crops, within the agricultural production framework (Winarno et al, 2021). A service provider refers to a farmer or any person within the agricultural community, regardless of whether they possess cultivable land, who owns one or more machines utilized on their farm (if applicable) and/or offers mechanization services to nearby farmers for a fee (Ustawi & Initiative, 2024).

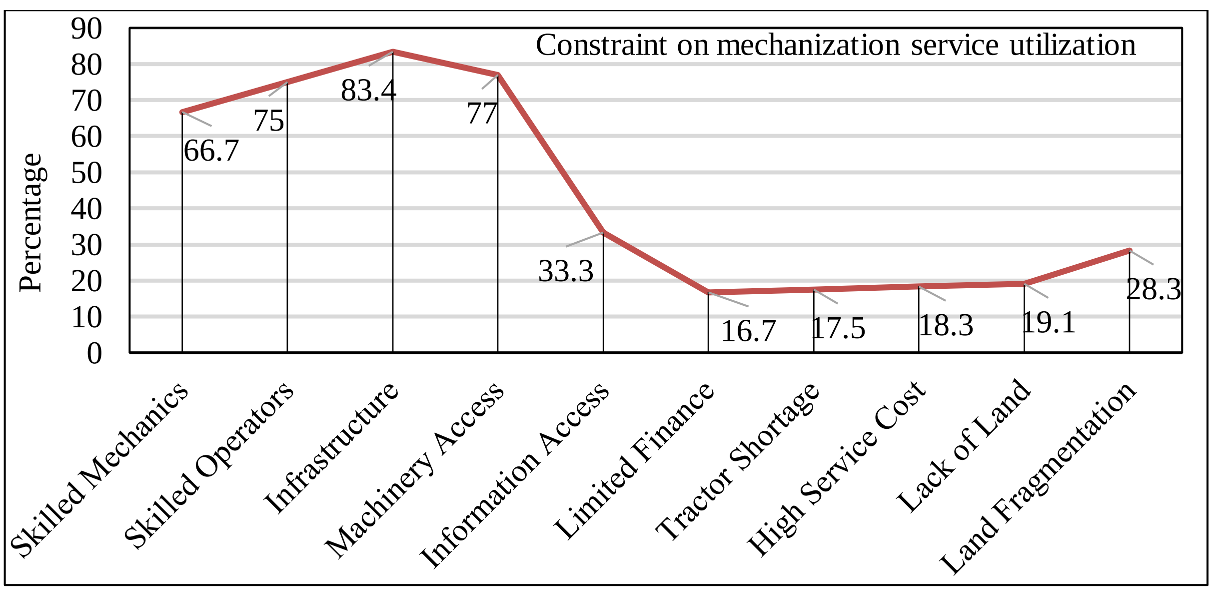

Figure 4. 8. Constraint on the mechanization service utilization

The predominant forms of mechanization rental services identified in the study area primarily involve tractor plowing. The rates for hiring these services are influenced by various factors, including the service's geographical location, the condition of the fields, the quality of the grain, and the negotiations conducted with farmers. Although farmers are generally able to afford these hiring services, they face significant obstacles in accessing agricultural machinery due to poor road conditions and the fragmentation of their land holdings. To address these challenges, farmers often collaborate with neighbouring farmers to pool resources and raise sufficient funds to meet the high costs associated with these services.

In summary, the main limitations concerning inputs consist of a lack of trained and skilled machinery operators, restricted access to machines and spare parts, prolonged downtime of tractors, and inadequate maintenance services. Moreover, the use of mechanization rental services is further faced by both physical and external factors, also poor road infrastructure, elevated machinery costs, the disjointed nature of land plots, steep landscapes, and difficult soil conditions.

4.9.Challenges faced by smallholder farmers and providers of mechanization services

Table 4.16 shows farmers' perceptions of farm machinery availability in the study area. Out of 126 respondents, 33.33% (42 farmers) strongly agreed and 43.65% (55 farmers) agreed that machinery is not readily available and scarcity of resources during peak operational periods, leading to delays. This means a total of 76.98% (97 farmers) acknowledged a shortage of farm machinery. On the other hand, 17.46% (22 farmers) disagreed, and only 5.56% (7 farmers) strongly disagreed, making up a total of 23.02% (29 farmers) who did not perceive machinery availability as a major issue. These results indicate that the majority of smallholder farmers in the area experience challenges in accessing mechanization services, particularly during peak agricultural periods. The findings indicate that a considerable majority, approximately 76.98%, acknowledge the shortage of farm machinery during both regular and peak operational times. Consequently, delays in farming activities, particularly during planting and harvesting, adversely affect crop productivity and overall farm performance.

Table 4. 16. Farmers' perception of farm machinery availability

Response Category	Percent	Frequency	Interpretation
Strongly Agree	33.33	42	Machinery is not readily available
Agree	43.65	55	Machinery is not readily available
Disagree	17.46	22	Machinery is available
Strongly Disagree	5.56	7	Strongly, the machinery is available
Total Agree (Strong + Normal)	76.98	97	Acknowledge the machinery shortage
Total Disagree (Strong + Normal)	23.02	29	Do not acknowledge the machinery shortage

Table 4.17 indicates that a significant portion of respondents (75%) found the working environment for service providers to be satisfactory or good, while 25% expressed dissatisfaction with their workplace conditions. Additionally, a substantial 83.4% of respondents reported inadequate road access, whereas only 16.67% considered the roads suitable for transporting farm machinery. These findings suggest that most agricultural mechanization service providers (AMSPs) perceived the overall working environment, including factors such as topography, farmer awareness, and climatic conditions, as conducive to service delivery. However, the lack of convenient road access highlights a shortfall in governmental infrastructure support.

Another challenge faced by AMSPs is the scarcity of skilled operators and mechanics. Specifically, 75% of respondents noted a lack of qualified operators (such as tractor and combine harvester drivers), and 66.67% reported insufficient mechanical expertise (as shown in Table 4.17). This indicates a significant deficiency in skilled labor for both operating and maintaining agricultural machinery, particularly among mechanics. Such a shortage may lead to increased machinery downtime, adversely affecting productivity.

Table 4. 17**.** Constraints on mechanization technology operators and technicians

Constraints	Very Poor		Poor		Satisfactory		Good	
	(Fr)	(%)	(Fr)	(%)	(Fr)	(%)	(Fr)	(%)
Workplace environment	3	12.5	3	12.5	13	54.17	5	20.83
Road accessibility	4	16.67	16	66.67	4	16.67	-	-
Presence of skilled operators	7	29.17	11	45.83	4	16.67	2	8.33
Presence of skilled mechanics	4	16.67	12	50	5	20.83	3	12.5
Availability of Machinery	13	54.17	8	33.3	3	12.5	-	-
Level of Government support	3	12.2	12	50	8	33.3	3	4.2
Spare part supplier	-Private (95.8%) -Government (4.2%)							

Source: - Field survey data- 2016/17, Fr. - Frequency; % - Percent

Trained operators were absent in various agricultural organizations, as indicated by key informant interviews and focus group discussions. Farm machinery operators commenced their duties without any formal training, while the equipment itself has evolved to include computerized systems and advanced hydraulic mechanisms. In Ethiopia, there is a notable absence of operators skilled in the use of modern agricultural machinery within these farming enterprises. The primary challenges identified include the intricate nature of the machinery and the lack of trained operators.

Smallholder farmers in the study area encounter several obstacles, including the high costs associated with hiring services, the unavailability of such services, and delays in receiving them during peak operational periods (see Table 4.18). The findings also highlighted land fragmentation and limited land availability as significant barriers to utilizing tractors for plowing. Specifically, approximately 28.3% and 19.05% of respondents identified these two issues as constraints, respectively. Additionally, around 18.3%, 17.5%, and 16.67% of respondents cited the high cost of tractor services, a shortage of tractors, and insufficient financial resources as further impediments to the use of tractors for land cultivation.

Table 4. 18**.** Major constraints of using agricultural machinery for operating land**.**

Constraints	Frequency	Percent (%)
Elevated service charge rates	23	18.30
Fragmentation of land	36	28.30
Insufficient financial resources	21	16.67
Scarcity of land	24	19.05
Deficiency of tractors	22	17.50

Finance represents a significant barrier to the establishment of mechanization rental services for acquiring agricultural machinery and inputs. The terms of credit and the potential for default on loans intended for farm machinery have created substantial challenges in gaining access to various official finance institutions. This situation has prompted a reassessment of the credit availability framework. Recently, some farmers have begun to invest in more affordable tractors, facilitated by improved access to financing options.

Respondents indicated that agricultural technology manufacturers face limitations due to a skills gap, which encompasses the technical ability to accurately replicate machine components and the capacity to meet specified quality and timeliness standards. A recurring concern among manufacturers is the high cost and scarcity of raw materials that meet the necessary specifications. As the prices of manufacturing materials continue to rise, the cost of high-quality assembled products becomes prohibitively expensive for farmers compared to other available manufactured goods. In general, it's important to encourage local manufacturing to lessen dependence on imports and boost the production of certain machinery parts. However, farmers often hesitate to use mechanization services for various reasons, such as having small plots of land, not having enough money to afford these services, being unaware of the services that exist, and facing difficulties due to the landscape.

4.10. Access to infrastructure and institutional services for farmers

The existence of infrastructure and institutional support services is crucial in influencing the degree of farm mechanization in developing nations such as Ethiopia, particularly within the study area. Essential components include roads, irrigation systems, power sources, telecommunications, farm machinery rental services, and maintenance facilities (garages), all of which are vital for smallholder farmers. Those farmers who have convenient access to roads and market outlets are more likely to acquire farm machinery. Conversely, the distance of farmers' homes from markets or towns, especially when not situated near public roads, poses a barrier to the adoption of advanced farming equipment. As a result, this limitation adversely affects the productivity of the farmers.

Table 4.19 indicates that, on average, farmers in the study region have their farm plots situated 27.5 km from the main road. The shortest distance recorded was near the main road, while the farthest distance reached up to 50 km. Smallholder farmers with plots near the main road benefit from improved access to infrastructure and transportation services. This proximity allows them to utilize farm machinery, such as tractors, promptly, facilitating the utilization of mechanization inputs to their fields and the transportation of harvested products. Additionally, farmers who have access to roads are in a stronger position to negotiate and deliver their goods to market centers, whether to wholesalers or retailers, often obtaining better prices. Furthermore, the presence of transportation facilities minimizes market distance and enhances marketing options.

Table 4. 19**.** Farm machinery accessibility from farm plots

Description	Number	Mini (km)	Max (km)	Mean (km)	STD (km)
Distance from the main road	126	5	50	27.5	12.99

The machinery service center represents an essential component of infrastructure for the mechanization of agriculture. Within the study area, there is a notable absence of adequately serviced centers equipped with machinery that provide extensive technical repair and maintenance services, except for a few minor facilities.

Moreover, the existence of organizations that provide training and educational resources for farmers can greatly improve the uptake of agricultural technologies. When farmers are provided with information and support concerning new technologies, they are more inclined to embrace innovative ideas that can boost the productivity of smallholder farms.

4.11. Understanding and practice of AT among smallholder farmers

In the study area, the utilization of agricultural mechanization services significantly enhances the utilization of farm machinery. This approach facilitates technology transfer, aids farmers in addressing challenges, and encourages their active participation in agricultural knowledge and information. Consequently, smallholder farmers have increased their understanding and awareness of agricultural technology.

Farmers' decisions to adopt farm machinery or advanced agricultural technologies in their operations are typically influenced by their awareness and understanding of the technology's existence and its potential advantages for boosting farm productivity. As illustrated in Figure 4.7, 44% of farmers strongly disagree regarding the availability of farm machinery, while 33.3% express disagreement, and 10.2% were neutral in their response. Conversely, only 12.5% of respondents acknowledge the presence of farm machinery, noting the availability of certain tractors and other technologies in the area.

The findings suggest that those farmers who strongly assert the non-availability of farm machinery tend to have their fields situated far from main roads or urban centers. In contrast, those who recognize a shortage of farm machinery during critical periods are typically located closer to these thoroughfares. Overall, the study area does exhibit some availability of farm machinery at crucial times, which has contributed to enhanced crop production.

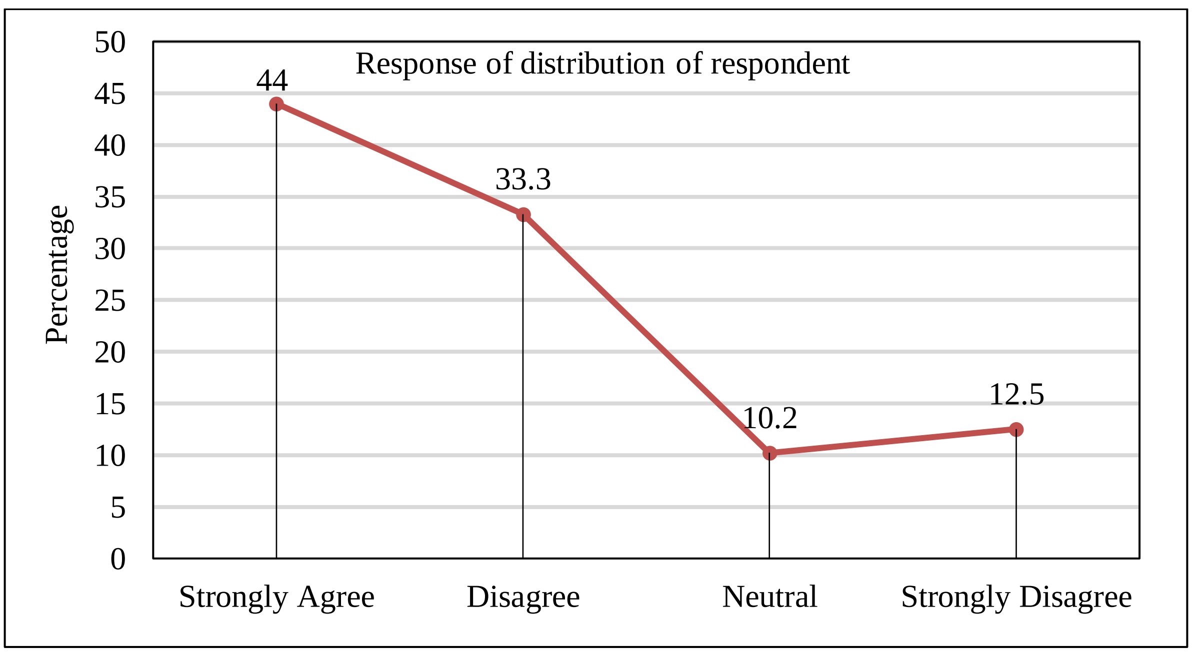

Figure 4. 9. Demand and availability of farm machinery

Respondents generally indicated a deficiency of farm machinery within the study area. This suggests that, despite having the demand and capacity for various mechanization services and a willingness to pay, they were unable to locate farm machinery at the most suitable times. Although the quantity of farm machinery in the area has seen periodic increases, shortages were noted during peak operational periods. This situation hinders timely access to equipment for farmers, ultimately reducing their crop yields.

The presence of advanced agricultural machinery in nearby regions plays a crucial role in the utilization of farm machinery by smallholder farmers. As shown in Table 4.19, all farmers in the study area rely on custom hiring to access farm machinery services. Through this arrangement, farmers can obtain machinery along with operators, alleviating them of the responsibilities related to maintenance and lubrication.

Table 4.20 further illustrates that the payment method for mechanization services in the study area is strictly cash-based. Consequently, farmers must make cash payments during agricultural operations, as there are no credit services available for farm machinery use in the region. This absence of credit options restricts the poorest smallholder farmers from acquiring the necessary machinery, despite their interest. Given these findings, if various stakeholders were to provide credit services to smallholder farmers, it could lead to an increase in crop production, as agricultural tasks could be performed using farm machinery at optimal times.

Table 4. 20**.** Acquiring and payment method of machinery service in the study area

Machinery Service	Frequency	Percent
Custom hiring	63	100.0
The payment method is cash	63	100.0

In general, numerous smallholder farmers within the study area have adopted improved agricultural mechanization technologies. While a majority of these farmers utilize machinery for their farming activities, several factors contribute to the reluctance of some to embrace such technologies. These factors include a lack of awareness regarding the comprehensive advantages of mechanization, insufficient technical knowledge, illiteracy, inadequate promotion of available machinery, and the high costs associated with renting equipment.

Traditional farming methods often hinder timely land operations due to their time-consuming nature, particularly for those lacking access to farm power. To enhance operational timeliness, mechanization presents a viable solution, as machines typically operate more swiftly than human labor or animal power. This efficiency can lead to significant time-related benefits, ultimately resulting in increased crop yields. Consequently, farmers in the study area have observed that operations conducted promptly yield greater results compared to those executed later.

Despite the limited extent of agricultural mechanization, there is evidence of evolving farming practices and a shift in the sources of farm power within the study area. Farmers are increasingly interested in utilizing machinery as a substitute for labor and draft animal power. However, the adoption of machinery in agricultural practices remains inadequate. Services related to seed broadcasting, planting, and seed covering are not sufficiently available. Nevertheless, the overall availability of mechanization rental services in the study area has improved, particularly for agricultural operations such as tractor ploughing, chemical spraying, and combine harvesting, which are the most accessible services.

In general, the study indicated that there was a high level of mechanization variations among the districts in pre- and post-harvest operations. Accordingly, the 1st and 2nd ploughing, and harvesting with combine harvesters were the most widely known practices in the study area, with proportions of 72, 47, and 86%, respectively. In addition, the respondents also answered that there was mixed operation (animal and tractor) which was 15 and 19% for 1st and 2nd ploughing, respectively, while 30% weed control method by mixed operation (manual and chemical), and harvesting of crops by mixed operation (manual and combine harvesters) was 24% (Figures 4.3 and 4.5).

4.12. Awareness and source of information on agricultural mechanization technologies

This research investigated the information sources and the level of awareness among smallholder farmers concerning agricultural mechanization and technological innovations. The data gathered indicates a variety of channels through which farmers obtain information about agricultural methods and mechanization. As illustrated in Table 4.21, development agents emerged as the predominant source of information, with 33.33% of participants depending on them for advice. Other significant sources included media (16.67%), neighbors (10.32%), research institutions (11.11%), and importers and assemblers (19.05%). Furthermore, a smaller fraction of farmers (13.79%) identified additional sources, such as non-governmental organizations (NGOs).

Table 4. 21**.** Awareness and source of information on agricultural mechanization technologies

Sources of Information	Frequency	Percent
Medias	21	16.67
Development Agents (DA)	42	33.33
Neighbours	13	10.32
Research centres	14	11.11
Importer and assembler	24	19.05
Others (e.g., NGOs)	12	13.79
Awareness Status	**Frequency**	**Percent**
Conscious of the existence of research and technology multipliers	47	37.3
Unconscious of the existence of research and technology multipliers	79	62.7

In evaluating farmers' awareness of research and technology multipliers, it was revealed that a substantial portion (62.7%) of farmers lacked knowledge of these initiatives, whereas 37.3% were informed. This notable discrepancy in the distribution of agricultural technology and research among smallholder farmers highlights the necessity for enhanced access to these vital resources. Furthermore, the study illuminates the differences in information sources and the farmers' awareness levels, emphasizing the critical need for focused outreach and educational initiatives to enhance understanding of technological advancements and their possible advantages.

4.13. The effect of financial institutions on the uptake of AT

This part looks at how capital and credit resources affect the adoption of agricultural technology. The results are shown in Table 4.22.

Table 4. 22**.** Capital and credit facilities for the adoption of agricultural technology

Variables	SA %	A %	U %	D %	SD %
Cost of technology	64 (50.8)	54 (42.86)	8 (6.35)	0.0	0.0
Availability of tools and equipment	67 (53.2)	46 (36.5)	13 (10.32)	0.0	0.0
Availability of cash	68 (53.97)	36 (28.57)	0.0	4(3.2)	7 (5.56)
Availability of credit facilities	88 (69.8)	13 (10.32)	2 (1.6)	23 (18.25)	0.0
Exposure to technology	73(57.94)	25(19.84)	0.0	10(7.94)	18 (14.29)

Key: n = 126, SA = strongly agree, A = agree, U = undecided, D = disagree and SD = strongly disagree

The findings revealed a range of perspectives among the respondents. Notably, 93.66% identified the cost of technology as a critical factor influencing technology adoption among smallholder farmers, while 6.35% remained uncertain. Additionally, a significant majority, 89.7%, believed that the availability of tools and equipment plays an important role in the adoption process. Furthermore, 82.54% of respondents indicated that access to cash is a determining factor for technology adoption, in contrast to 8.76% who disagreed with this view. Regarding the exposure of smallholder farmers to technology, 57.94% strongly agreed, 19.84% agreed, 7.94% disagreed, and 14.29% strongly disagreed.

4.14. The impact and significance of training on the uptake of AT

The data reveals that 45% of participants strongly concurred that farmers are provided with training in agricultural technology, while 25% agreed, 9% remained neutral, and 21% disagreed. Furthermore, 58% of respondents conveyed the belief that farmers are educated in advanced yield-enhancing technologies, including improved seed varieties, with 6% undecided and 36% disagreeing. The results indicate that 55% of respondents stated that farmers receive training in the utilization of various tools and equipment, whereas 14% were undecided and 31% disagreed. A notable majority (61%) of respondents believed that extension workers engage in in-service training; however, 11% were uncertain, and 31% argued that these workers do not undergo such training. Insights from interviews disclosed that extension workers frequently reiterate the same messages to the same groups, and the information disseminated is often outdated.

Table 4. 23**.** Influence of training on adoption of agricultural technology

Skills gap variable	SA %	A %	U %	D %	SD %
Training of farmers in agricultural technology	45.0	25.0	9.0	11.0	10.0
Farmers receive instruction on enhanced yield-increasing technologies, including superior seeds.	55.0	3.0	6.0	5.0	31.0
Farmers are educated on the utilization of various tools and equipment.	23.0	32.0	14.0	9.0	22.0
Extension workers participating in service training.	38.0	23.0	11.0	18.0	13.0

Key: n = 126, SA = strongly agree, A = agree, U = undecided, D = disagree, and SD = strongly disagree

4.15. Availability and distribution of agricultural technology

Our physical observations indicate that four-wheel tractors and combines are widely accessible and well-distributed. These machines are substantial in size, feature intricate designs, require extensive turning radii, and are economically viable options based on prior distribution analyses. Below, Table 4.24 presents the frequency and percentage of each variable corresponding to each determinant factor. This table is derived from structured questionnaires administered to end-users, dealers, and both private and governmental stakeholders.

Table 4. 24. The availability and distribution of the tractor and combiner

Factors	Variables	N	Percent	Factors	Variables	N	Percent
Shashemene, Arsi Negele, and Siraro District.	Bad	49	38.89	After-sales service	Bad	54	42.86
	Fair	45	35.75		Good	42	33.33
	Good	32	25.39		Fair	30	23.81
Durability Of Machines	Bad	49	38.89	Combiners and Tractors are effective	DA	46	36.51
	Fair	40	31.75		PA	48	38.10
	Good	37	29.37		CA	32	25.40
Performance Test	No	120	95.23	Utilization of Combiners and Tractors	Bad	31	24.60
	Yes	6	4.77		Fair	40	31.75
					Good	55	43.65
Ownership	By Credit	85	67.46	Operating Skill	Bad	85	67.5
	Buying	41	32.54		Fair	25	19.84
					Good	16	12.70
Machinery Status	Bad	27	21.43	Pieces of training Given	Bad	59	46.83
	Fair	54	42.86		Fair	41	32.54
	Good	45	35.71		Good	26	20.63

Sample size (n) = 126; Key: DA = Don.t agree, PA = partially agree, and CA = completely agree

As presented in Table 4.24, the allocation of tractors and combines within the targeted regions reveals that Arsi Negele accounts for 38.89%, Shashamene woreda comprises 35.75%, and the remaining 25.39% is attributed to Siraro woreda. A significant majority of these tractors and combines are acquired through credit, totalling 67.46%, while 32.54% are purchased outright. Overall, the condition of the machinery is subpar, with 21.43% classified as poor, primarily because 95.23% of the tractors surveyed have not undergone performance testing. Furthermore, both operators and owners have not received any training, leading to a notable 46.83% of them lacking adequate training opportunities, and 67.5% of drivers exhibiting insufficient operational skills.

Among the participants, about 36.51% express dissatisfaction with the effectiveness and capabilities of the tractors and combines, highlighting a deficiency in the effective use of agricultural machinery and technology. This situation is further underscored by the fact that approximately 42.86% of respondents do not effectively utilize the tractors and combines in terms of after-sales service.

4.16. The demand for the accessibility of spare parts for AMMT

Table 4.25 shows that the accessibility of agricultural machinery spare parts reveals notable insights into the perceptions of respondents, with spare part accessibility (43.65%) indicating that spare parts were accessible, and non-spare parts (56.35%) to accessibility. Ethiopia has no tractor or combine industry depends on imports, except for some technologies and tractor assembly units. Each year, the number of combines and tractors increases due to higher needs and demand. This industry shows a lot of growth potential. The use of tractor parts and other technologies is affected by several factors. Many types of tractor parts are used in different tractor models. Some parts last only a short time, while others are made for longer use.

Table 4. 25. Accessibility of agricultural machinery spare parts demand

Variable	Frequency	Percent	Mean	SD
Spare part accessibility	55	43.65	0.87	0.75
Non-spare part accessibility	71	56.35	0.56	0.33
Total	126	100	-	-

In Ethiopia, the absence of a tractor manufacturing facility has resulted in a shortage of spare parts producers. Consequently, the overall demand for parts and components is expected to rise in the future due to the growing utilization of tractors in agricultural fields, which will need to be satisfied by local manufacturers and imports. Importers of agricultural machinery import different machines without spare parts. This is because they are allowed and licensed to import only farm machinery. On the contrary, in the study area, there were some spare parts importers to tackle the problem. The problem persists been traveling long-range distances like Addis Ababa, Adama, and Shashamene, which creates delays in farm machinery maintenance and timely farm operation. Due to this, farm plow lags result in time pulverization of soil, poor circulation of air, and poor absorption of water in the soil.

The findings suggest that improving the availability and distribution of spare parts through local service centers, private suppliers, and public-private partnerships would enhance the sustainability and effectiveness of mechanization service utilization. Addressing this gap is essential to minimize operational delays and maximize the utility of mechanized farming tools.

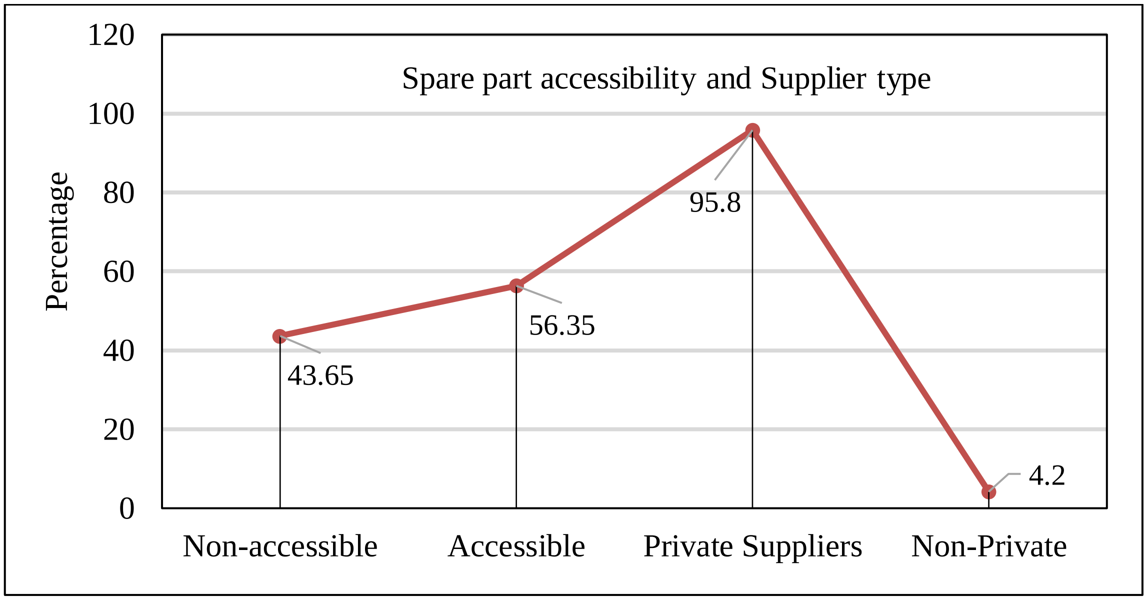

Figure 4. 10. Spare part accessibility and suppliers

4.17. Type of farm implements used by smallholder farmers

Farmers in the study area use tools to improve agricultural productivity. The research shows that most farmers (55%) reported not using farm implements in their farming practices as part of agricultural mechanization, and 45% of farmers can use implements to enhance agricultural productivity and production.

Farmers used various agricultural tools on their farms. Table 4.26 below shows the different types of tools that the farmers used.

Table 4. 26**.** Types of farm implements used by farmers

Agricultural Implement	Frequency	Percentage (%)
Plough and Harrow	35	27.78
Planter	18	14.30
Draught Power	18	14.30
Sprayer	2	1.60
Feed Blocker	15	11.90
Weeders	9	7.14
Spreader and Irrigators	8	6.35
Hand Tools	21	16.67

Table 4.26 displays the most commonly used farm tools by smallholder farmers in the study area. The findings indicate that the Plough and Harrow were the primary tools utilized by farmers because tractors are quick, precise, and require less labor. Hand tools have been ranked as the second most popular form of agricultural mechanization since farmers have trusted hand

tools since their childhood, when they worked in their home gardens and fields. Additionally, planters and draft power are other tools employed because they simplify the planting process, making it faster and reducing the physical labor involved. Livestock farmers also use feed blockers as part of improved agricultural practices. The least utilized tools were spreaders and irrigators, as farmers tend to favor other options due to cost concerns.

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4.17.1. Benefits of using agricultural mechanization on the farm

Table 4.27 below shows the advantages of agricultural mechanization for smallholder farmers in the West Arsi zone. The use of agricultural mechanization has led to significantly better yields from various crops, made possible by this technology.

Table 4. 27**.** Benefits of using agricultural mechanizations

The use of mechanization	Frequency	Percentage (%)
Improved farming output and efficiency	65	51.60
Higher profits for farmers	25	19.84
More frequent crop planting	36	28.57

These results were shown according to Mdoda et al. (2022), agricultural mechanization has improved production and productivity for smallholder farmers in Ethiopia. It has greatly supported the farming community's overall economic growth. Smallholder farmers who use agricultural mechanization have seen higher farm returns compared to those who do not use it. These findings are consistent with Yamin et al. (2011) that using mechanization results in greater yield per hectare and increased gross income compared to non-mechanized farms. Agricultural mechanization has significantly contributed to and enhanced cropping intensity.

4.17.2. Challenges faced by smallholder farmers

Many farmers indicated that the lack of nearby mechanization centers is the biggest issue impacting their access to and use of agricultural machinery on their farms, which greatly reduces their productivity. Table 4.28 illustrates the challenges faced by farmers in utilizing agricultural mechanization.

Table 4. 28**.** Challenges faced by smallholder farmers

Challenge Faced	Frequency	Percentage (%)
Lack of agricultural machinery centers	53	42.06
Money issues	43	34.13
Lack of knowledge	30	23.81

Numerous farmers have reported that financial limitations represent a significant obstacle to the expansion of their agricultural operations. The costs associated with inputs, infrastructure, and the purchase or rental of equipment are major barriers to sustainable farming development. Furthermore, a lack of knowledge emerges as the most pressing challenge for farmers, which in turn detrimentally impacts farm productivity. The findings of the study indicate that farmers are insufficiently informed, leading to a lack of awareness regarding agricultural mechanization that could improve their output. This situation is problematic, as effective farming relies heavily on the application of agricultural mechanization to boost productivity. Consequently, the deficiency in knowledge and awareness among farmers adversely influences both their productivity and overall well-being.

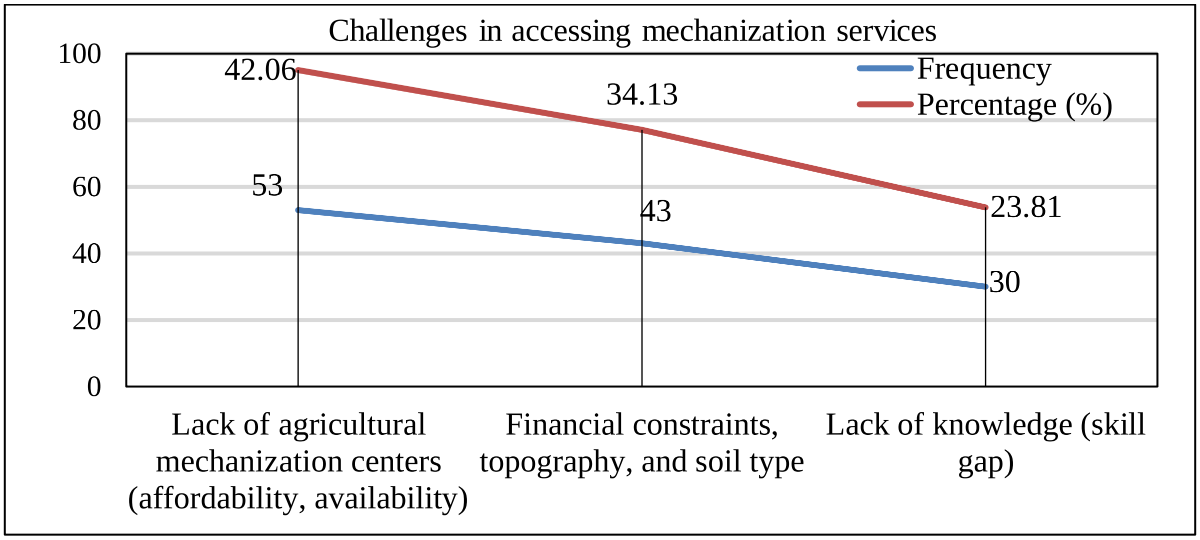

Figure 4. 11. Challenges facing smallholder farmers

4.18. Type of agricultural machinery used by smallholder farmers

The agricultural machinery and technology Table 4.29, like tractors, is the most commonly used equipment, with 25.4% of respondents using them, followed by shellers at 28.57%, and combiners at 22.3%. These individual machines suggest that tractors and shellers play a crucial role in daily farming tasks, particularly in land preparation and post-harvest processing. While a smaller portion of respondents (11.11%) use all three machines together (tractor, combiner, and sheller), it indicates that larger, more mechanized operations are adopting a full range of machinery for efficient farming. The data also reveals that combinations of two machines, such as the tractor and combiner or tractor and sheller, are less common, possibly reflecting different farming needs or smaller-scale operations. Overall, the data suggests that farmers typically select equipment based on their specific needs, with tractors and shellers being the most widely used, while more comprehensive machinery systems are used by fewer respondents.

Table 4. 29. Types of agricultural machinery and technology used

Type of agricultural Machine	Frequency	Percentage (%)
Tractor	32	25.4
Combiner	28	22.3
Sheller	36	28.57
All (Tractor, Combiner, and Sheller)	14	11.11
Tractor and Combiner	5	3.97
Tractor and Sheller	5	3.97
Combiner and Sheller	6	4.76
Total	126	100

4.19. Source of agricultural mechanization service utilization in the study area

In the household interviews, most respondents (50%) received mechanization services from private service providers, while 42% obtained them from farmers' unions and cooperatives, and 8% from a youth group. This indicates that cooperatives mainly offer mechanization services to a portion of their members. On average, the farms of the interviewed households are situated 27.5km from the road, with distances ranging from a minimum of 5km to a maximum of 50km.

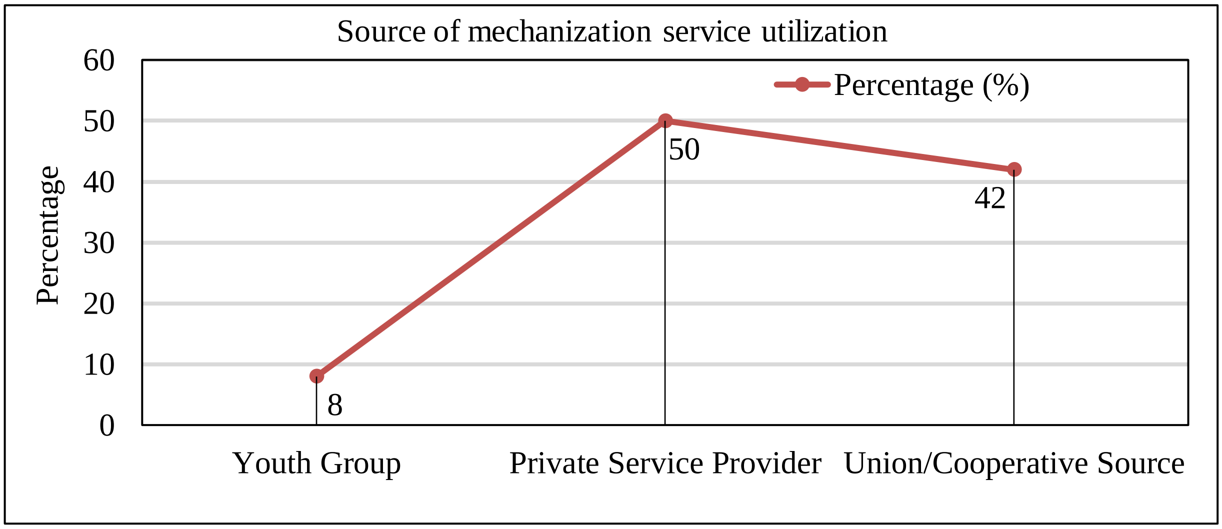

Figure 4. 12. Source of mechanization service utilization

The presence of service providers in the area is crucial for rental service choices among the households surveyed. Of 42.1% of respondents reported that there are a few tractor service providers nearby, while 57.9% mentioned that very few are available in their localities. Many respondents noted that they do not receive the service promptly when required.

The focus group discussion emphasized that the accessibility of mechanization services is an important factor in decision-making. Likewise, respondents pointed out that there are very few (48.1%) and few (51.9%) combined harvester service providers in their area, and only a small number believed they could get the service quickly when needed.

Table 4. 30**.** Source of agricultural machines and technology in the study area

Source of Agricultural Machine	Frequency	Percentage (%)
Development Station	29	23.02
Cooperative	34	26.98
Private service provider	46	36.51
Dealer	10	7.94
Unions	7	5.56
Total	126	100.0

Table 4.31 The study reveals that institutional facilities are widely available to farmers in the study area, but there are still some gaps in access. Specifically, 73.02% of farmers have access to credit services, which provide essential financial support for agricultural activities. Similarly, 77.77% of farmers benefit from extension services, which offer expert advice to improve farming practices. The highest access rate is for market information, with 83.33% of farmers using it to make informed decisions about selling their produce. However, 26.98% of farmers lack access to credit services, 22.23% do not have extension services, and 16.67% are without market information. These gaps indicate that while the services are largely available, there are still portions of the farming population who face challenges in accessing them.

Table 4. 31. Institutional facility in the study area

Facilities	Responses	Frequency	Percent
Credit services	No	34	26.98
	Yes	92	73.02
Extension services	No	28	22.23
	Yes	98	77.77
Market information	No	21	16.67
	Yes	105	83.33

Therefore, from the above table, institutional facilities are essential to supporting agricultural activities, and their availability and utilization are key to improving productivity in rural areas. These facilities provide farmers with the necessary resources, guidance, and information to enhance their farming operations. This study explores the access to and use of institutional facilities, specifically credit services, extension services, and market information, within the study zone to assess how these services are impacting agricultural practices and identify potential gaps.

4.20. Agricultural mechanization technical support and maintenance services

According to the report by Tesema et al. (2023), utilizing suitable agricultural mechanization services is essential for boosting agricultural productivity and securing food supply. Many Ethiopian farmers lack access to agricultural mechanization services, such as tractors, combine harvesters, and threshers. Various factors contribute to the restricted use of agricultural mechanization services in Ethiopia.

Smallholder farmers' access to efficient mechanization services and technologies has improved productivity and income levels in rural areas; however, agriculture faces challenges such as Restricted access to quality mechanization services and old technology leads to low productivity and income. Smallholder farmers, in particular, face challenges in obtaining mechanization services (Van Loon et al., 2020).

Table 4. 32**.** Technical support and maintenance services of machinery

Variable	Frequency	Percent (%)
On-time Service	60	47.62
Delayed Service	35	27.78
Frequent Breakdowns	20	15.87
Excellent Maintenance Support	6	4.76
Lack of Support	5	3.97

Figure 4.13 shows that On-time service (47.62%) indicates that a significant portion of agricultural machinery services is performed promptly, demonstrating that mechanics and operators possess the necessary skills to ensure machinery is available for use without excessive downtime, which is critical for maintaining productivity on the farm. Delayed service (27.78%) suggests that there are occasional delays in repairs and maintenance, which could be due to factors such as a lack of sufficient training for mechanics, poor availability of spare parts, or inefficient service systems. Delayed maintenance can result in longer periods of downtime, negatively affecting farm operations.

Frequent breakdowns (15.87%) point to potential issues with either the machinery's condition or the operator's handling. This could reflect poor preventive maintenance practices or insufficient technical knowledge among operators, leading to a higher frequency of breakdowns that disrupt farming activities. Excellent maintenance support (4.76%) shows that high-quality technical support is available, but not frequently experienced. This could be a need for more skilled technicians or better support systems to provide more consistent, high-quality maintenance. Lack of support (3.97%) reflects instances where there is insufficient technical support, potentially due to limited access to skilled labor or inadequate infrastructure. This gap in service utilization can hinder machinery performance and negatively affect agricultural productivity.

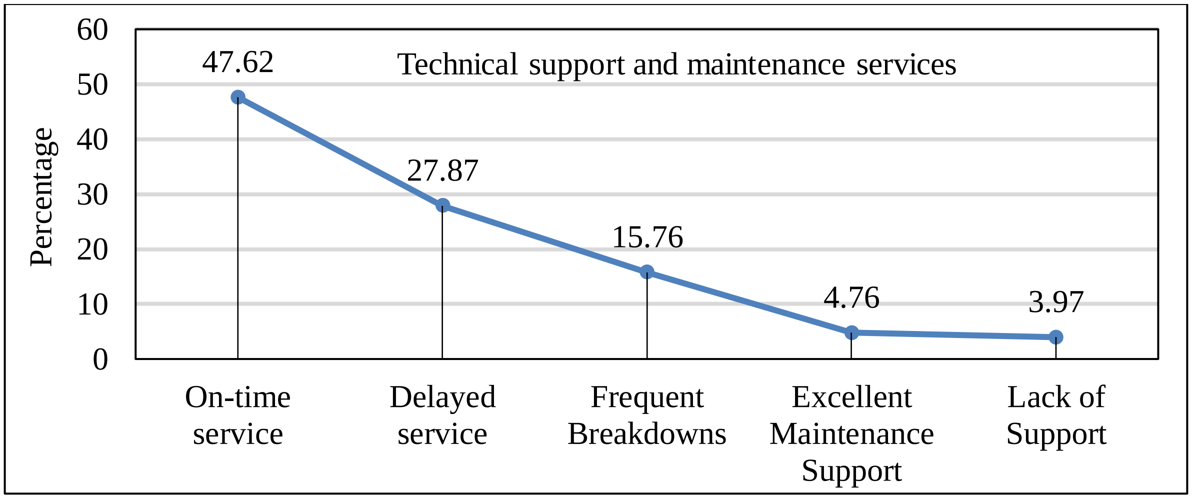

Figure 4. 13. Maintenance service delivery of machinery

4.21. Types and levels of farm mechanization technologies

Respondent households are using different types of farm mechanization technologies, with almost all households having agricultural tools powered by animals. The most common modern mechanization technologies are four-wheel tractors and combine harvesters, while only a few households have adopted two-wheel tractors and engine-driven stationary threshers.

In detail, 27.78% of households use four-wheel tractors, 22.23% use combine harvesters, and 23.81% are involved in some type of agricultural mechanization. Research from agricultural districts and zonal offices shows that a large number of households in the study areas are using farm mechanization (see Table 4.33).

Additionally, the results indicate that out of 126 respondents, more than 50% of households are using either combine harvesters or tractors. The main sources of farm machinery are mostly private owners and agricultural unions. In Ethiopia, the horsepower of tractors typically ranges from 20 to 130 HP (MOA, 2023).

Table 4. 33**.** Types and main reasons behind adopting farm mechanization technologies**.**

Description of variables	Frequency	Percent
Types of farm machinery used by households:		
Two-wheeled tractors	8	6.35
Four-wheeled tractors	35	27.78
Engine-powered threshers	25	19.84
Combine harvesters	28	22.23
Utilized any of these mechanization methods	30	23.81
Reasons to consider mechanization options:		
Limited workforce	28	22.23
High wages for hired farm workers	25	19.84
Expensive animal feed	54	42.86
To lessen work strain (improve quality of life)	19	15.08

Four key reasons have been found for using farm machinery. One major reason is that many respondents depend on agricultural animals for tasks like land tillage and threshing. The second most significant concern, cited by 22.23% of respondents, is the shortage of agricultural labor, which is driving the push toward farm mechanization. Moreover, the lack of both family and hired workers has turned into a serious issue, worsened by young people going to school and moving to cities for better chances. Hired help is frequently not available or too expensive because of high wages.

This wage increase may be attributed to the rising educational levels within society, leading many individuals to either refuse such labor-intensive work or demand higher compensation. Furthermore, the farming community's desire for a better quality of life and the modernization of agriculture emerged as another significant factor driving farm mechanization, with approximately 15% of respondents recognizing this as a key motivator.

4.22. Effect of agricultural mechanization service on crop productivity

The effect of mechanization service parameters on crop yield per hectare was evaluated using a linear regression model, which accounted for 63% of the differences in crop production. This suggests a strong connection between the twelve mechanization-related factors and yield results, with the model being statistically significant at $p < 0.01$. The remaining 37% of the variation could be due to other factors not included in the model, as noted in Table 4.34.

The regression analysis (Table 4.35) indicates that the type of machinery, cluster farming, farm size, and farming experience had a very significant positive impact on crop productivity, while spare part availability and the level of mechanization had a moderate effect. Most mechanization inputs (Table 4.36) enhanced crop yield, except for spare parts and distance, which negatively affected productivity.

Table 4. 34. Parameters to estimate crop production by multiple linear regression models

Variable	Coefficient (β)	Std. Error	t-Statistic	Sig.
Constant	2.435	0.578	4.21	0.000
Accessibility of machinery	0.612	0.125	4.90	0.000
Types of machinery used	0.443	0.133	3.33	0.001
Cluster farming	0.015	0.006	2.50	0.014
Age of the farmers' household	0.307	0.142	2.16	0.032
Education level	0.285	0.088	3.24	0.002
Family size	0.126	0.059	2.14	0.034
Farm size	0.551	0.118	4.67	0.000
Distance to service	-0.023	0.009	-2.56	0.011
Farm experience	0.017	0.007	2.43	0.016
Level of mechanization	0.218	0.094	2.32	0.022
Availability of spare parts	-0.492	0.105	4.69	0.000
Service quality	0.438	0.131	3.34	0.001

Note: significant at P<0.05; highly significant at P<0.01

Table 4. 35**.** Summary of parameter estimates of the multiple regression model

variable	R	R Square	Adjusted R Square	Std. Error of the Estimate
Model	0.866	0.75	0.724	0.94

Table 4. 36**.** ANOVA table for parameter estimates of multiple regression models

Variable	SS	df	MS	F	Sig.
Model	300	12	25.00	5.00	0.000
Residual	100	113	0.88		
Total	400	125			

SS-sum of squares, df- degrees of freedom, MS- mean square, F-f-statistic, Sig.- significance

Accessibility of machinery: This variable is results are statistically significant, showing a p-value of 0.000 and a coefficient of 0.612, indicating a positive effect of 61.2% on the utilization of mechanization services. In simpler terms, enhancing machinery accessibility by touch unit results in a 61.2% increase in mechanization usage. This factor is among the most critical enablers in your model.

Farm size: With a p-value of 0.000 and a coefficient of 0.551, this variable is statistically significant, indicating a 55.1% increase in the use of mechanization. Larger farms benefit more from machinery due to economies of scale and greater operational demands.

Availability of spare parts: This finding is also significant (p = 0.000), but it has a negative coefficient of -0.492, which translates to a -49.2% effect. Although spare parts are technically available, this result suggests issues such as poor quality, high costs, or limited usability, which contribute to a decline in service utilization.

Types of machinery used: With a coefficient of 0.443 and a p-value of 0.001, this variable is statistically significant, indicating a positive impact of 44.3%. Increased diversity and specialization of equipment enhance the likelihood that farmers will adopt mechanization.

Service quality: This variable is also significant (p = 0.001), with a coefficient of 0.438, indicating a 43.8% positive effect. Farmers prioritize reliable, high-quality service, which enhances satisfaction and encourages repeat usage.

Education level: With a coefficient of 0.285 and a p-value of 0.002, this variable is statistically significant, indicating that it increases the adoption of mechanization by 28.5%. Educated farmers tend to be more aware of the benefits of technology and are more effective in utilizing available services.

Cluster farming: This variable shows statistical significance (p = 0.014) with a small positive coefficient of 0.015, which means a 1.5% increase. Joining group farming enables farmers to combine resources and utilize shared mechanization services.

Distance to service: With a negative coefficient of -0.023 and a p-value of 0.011, this variable is statistically significant and is associated with a 2.3% decrease in service usage. Increased distance creates logistical and cost barriers that discourage mechanization.

Age of the household head: This variable is statistically significant ($p = 0.032$) with a coefficient of 0.307, indicating a 30.7% increase in the use of mechanization. Older farmers might have greater experience and could be in a better position to use these services.

Family size: With a p-value of 0.034 and a coefficient of 0.126, this variable indicates a positive effect of 12.6%. Larger households may adopt mechanization to enhance productivity and decrease reliance on labor.

Farm experience: This variable is statistically significant ($p = 0.016$) with a coefficient of 0.017, indicating a 1.7% positive effect. Experienced farmers demonstrate greater confidence and efficiency in utilizing mechanization tools.

Level of mechanization: With a coefficient of 0.218 and a p-value of 0.022, this variable is statistically significant, indicating a 21.8% increase in usage. Farmers who are already utilizing certain types of machinery are more likely to enhance or expand their mechanization practices.

R-squared value: The statistical outcome of $R^2 = 0.75$ indicates that 75% of the variation in the utilization of agricultural mechanization services can be attributed to factors such as machinery accessibility, type of machinery, farm size, service quality, and farming experience. This suggests that these mechanization-related variables have a significant and direct impact on the effectiveness with which farmers utilize mechanization services.

Regression validity: A regression analysis is considered valid when it shows a high R-squared value, a significant F-statistic ($p < 0.05$), and significant individual predictors ($p < 0.05$). Additionally, a low standard error and logically consistent coefficients confirm the model's accuracy and reliability.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The research evaluated how effective the use of agricultural mechanization services is and examined the condition of small-scale farming systems in the area studied, along with the factors influencing the adoption of agricultural mechanization technologies. The results showed that smallholder farmers in the area encounter many difficulties in adopting and using agricultural mechanization technologies. These difficulties consist of expensive machinery, a shortage of trained and skilled operators, a lack of available machines and spare parts, significant tractor downtime, and restricted access to quality mechanization services.

The study found that farmers with convenient road access, market outlets, and institutional support services were more likely to acquire farm machinery. However, the lack of well-equipped machinery service centers, limited training and education services, and inadequate infrastructure slowed down the acceptance and use of agricultural mechanization technologies.

Despite the availability of farm machinery increasing over time, 76.98% of respondents reported a lack of farming equipment, especially during busy operational periods. This shortage significantly minimizes crop productivity. The study also highlighted the importance of financial institutions, training, and awareness in promoting the adoption of agricultural technology.

To improve agricultural productivity and efficiency, it is essential to address these challenges by providing affordable and accessible mechanization services, training, and education to smallholder farmers. Furthermore, investments in infrastructure, institutional support services, and the establishment of well-equipped machinery service centers are crucial for promoting the adoption and utilization of agricultural mechanization technologies.

Overall, the results of this research are important for policymakers, agricultural institutions, and other stakeholders working to improve agricultural productivity and efficiency in small-scale farming systems.

5.2. Recommendation

The recommended findings based on this study, that smallholder farmers the easy access to agricultural mechanization services and that enhancing the adoption of modern technologies to boost service providers' understanding of farm machinery. This study's findings lead to the following suggestions for raising farm mechanization and service usage.

1. Expand mechanization service access in rural areas: Many smallholder farmers in remote areas of the West Arsi Zone encounter availability faced in accessing agricultural mechanization services due to a limited number of mechanization service centers and a lack of road access. To address these issues, it is recommended to establish new mechanization service centers in underserved kebeles and woredas. Additionally, promoting the use of digital mechanization units that can travel to remote farms during peak seasons would be beneficial. Strengthening the public-private partnership model will encourage local entrepreneurs to invest in service delivery. Furthermore, encouraging cluster-based service deployment, where nearby farmers can collectively access and share services, will enhance cost-effectiveness.

2. **Build technical and human capacity:** One of the critical gaps identified in the study is the shortage of skilled machinery operators, technicians, and maintenance personnel. Therefore, it is essential to develop structured training programs specifically targeting machinery operators, repair technicians, and service coordinators. These programs should include practical skill development within vocational and technical institutions, with a particular focus on agricultural machinery. Additionally, continuous refresher training should be provided through extension programs to ensure that participants remain updated on maintenance, operation, and safety standards. It is also important to encourage the participation of women and youth in these training initiatives to address labor shortages and create employment opportunities in rural areas.

3. Enhance financial access for farmers and service providers: The financial issue of machinery and limited availability budget continue to pose significant barriers to the adoption and utilization of mechanization services. The following actions are recommended: introduce flexible financing mechanisms, such as lease-to-own schemes or long-term, low-interest loans specifically for agricultural machinery; strengthen credit facilities through rural microfinance institutions and cooperatives, supported by government-backed loan guarantees; provide targeted subsidies or tax incentives for farmers and service providers who invest in modern agricultural machinery; and facilitate group ownership models, enabling farmer cooperatives or organized youth groups to jointly purchase and manage machinery.

4. Strengthen infrastructure and spare part supply chains: Mechanization efficiency is often undermined by poor road access, lack of fuel stations, and the unavailability of spare parts. To mitigate this, invest in rural infrastructure development, especially feeder roads and fuel supply points. Support the establishment of spare part dealerships and maintenance workshops at district and kebele levels. Encourage local manufacturing and assembly of essential machinery and components to reduce dependence on imports. Create a coordinated supply chain system connecting service providers, dealers, and farmers to ensure timely and affordable access to parts and services.

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APPENDIX

Appendix I: Tables

Table 1. 1. Adoption rate of agricultural mechanization service

Adoption Technology Status	Frequency	Percent %
Adopting Mechanized Services	78	61.9
Not Adopting Mechanized Services	48	38.09

Table 1. 2**.** Cropping intensity index activity in the study area

Cropping Intensity	Frequency	Percent %
Low	45	35.7
Moderate	65	51.6
High	16	12.7

Table 1. 3. Field efficiency of agricultural mechanization technology

Efficiency Category	Frequency	Percent %
Productive time	74	58.7
Idle time	30	23.8
Maintenance and repair time	22	17.5

Table 1. 4**.** Capacity utilization of agricultural mechanization service

Utilization category	Frequency	Percent %
Low utilization	31	24.6
Moderate utilization	68	53.97
High utilization	27	21.43

Table 1. 5**.** Field capacity and work rate of agricultural mechanization technology

Field Capacity Category	Frequency	Percent %
Low	35	27.78
Moderate	70	55.55
High	21	16.67

Table 1. 6**.** Makers and origins of tractors and combine harvesters

Machinery	Model	HP	Make	Origin
Tractors	John Deere 5130	132	John Deere company	America
	Massey Ferguson 398	104	AGCO	America
	New Holland 110-90	120	FIAT Motors Corporation	UK
	Case IH Puma 175	175	Case Company	USA
Combine Harvesters	John Deere 7000	160	John Deere Company	America
	New Holland 80-66s	120	FIAT Motors	UK
	Class Combine Dominator 68's	150	Class	Germany

Table 1. 7**.** Agricultural mechanization: existing service providers

Types of service providers	Number of service providers
Private machinery services providers	1500
Youth/women group machinery service providers	300
Cooperative union machinery service providers	199
Primary cooperative machinery service providers	178
Cooperative agricultural machinery service centers	11

Source: National Agricultural Mechanization Strategy (MOA, 2025-2034)

Table 1. 8**.** Agricultural mechanization: new service providers and centers

Types of service providers	Number of service providers
New private machinery services providers	40,000
Cooperative unions involved in AMSP	11
Primary cooperatives involved in machinery service utilization	200
Youth/women group machinery service providers	300
established private innovation incubation centres	10

Source: National Agricultural Mechanization Strategy (MOA, 2025-2034)

Table 1. 9. Crop grown in selected district with land size (ha) and production (qt)

	Wheat		Teff		Maize		Sorghum		Total	
Woreda	Land	Prod.	Land	Prod	Land	Prod.	Land	Prod	Land	Prod.
Shashamene	920	177,000	325	9,800	300	5,605	135	1,575	1,680	193,980
Arsi Negele	800	144,000	295	8,330	250	4,425	125	1,125	1,470	157,880
Siraro	780	134,400	275	7,350	245	3,835	120	900	1,420	146,485
Total	2,500	455,400	895	25,480	795	13,865	380	3,600	4,570	498,345

Table 1. 10**.** Farm machinery dealers in the study area

Machinery dealers/importers	Machinery type
Hagbes PLC	The Nova combine harvester.
Adeb Engineering,	New Holland tractors and combine harvesters.
Adama Agricultural Machinery Industry	A cherry tractor with its implements
Kegna Agricultural Equipment Manufacturing and General Trading PLC & Gedeb Engineering	John Deere tractors with their implement
Kaleb Farmers House	Claas combine harvester
Ries Engineering	Massey Ferguson tractors and combine harvesters.
Ultimate Motors PLC	Landini tractors
Woreta International Business PLC	Case IH tractors

Table 1. 11**.** National data on major agricultural mechanization technologies

Machine type	Number by the 2023/24 production season
Tractors (10–250 hp)	19,690
Combine harvesters	6,358
Motorized thresher	10,348
Irrigation pumps	333,775

Source: MoA (2023/24): MOA Annual Performance Report (Unpublished).

Table 1. 12**.** Study area data on farm mechanization (combine harvester and tractors)

Machine type	Number of machines by zone		
	Arsi	West Arsi	Bale
Tractors	272	395	155
Combine harvester	79	187	77

Source: Ministry of Agriculture (2023), Development Bank of Ethiopia (2018) (Unpublished).

Table 1. 13**.** Machinery use intensity by zone in the study area

Machine type:	Mechanization operated by a machine at once		
	Arsi	West Arsi	Bale
Four wheel tractors	NA	42%	43%
Combine harvesters	NA	45%	41%

Source: Ministry of Agriculture (2023), Development Bank of Ethiopia (2018) (Unpublished).

Letter of transmittal for data collection

September 2016.

Sir householder:

I am a postgraduate student studying for a Master of Agricultural Machinery Engineering at the University of Adama's School of Mechanical, Material, and Chemical Engineering. I am researching to evaluate how effective the agricultural mechanization service offerings are in the West Arsi zone of Oromia. I am gathering data for this study using the attached questionnaire and interview schedules. I kindly ask that you fill out the questionnaire, providing all necessary information to assist with the research. Please use the space provided to give the requested information as accurately and honestly as you can. The information you provide will be kept confidential and will only be used for this study.

Thank you.

Yours faithfully,

Mr. Yeshigeta Bayu Awigchew

ID. PGR/28223/15

Phone No: +251953988997

Appendix II. The survey questionnaire

Assessment of the effectiveness of agricultural mechanization services utilization:

A case study of the West Arsi Zone, Oromia Region, Ethiopia.

MSc Thesis research survey questionnaire

Prepared by: YESHIGETA BAYU

(MSc Student, Adama Science and Technology University)

Introduction

The purpose of this interview is to collect information about rural households' access to both on-farm and off-farm mechanization services. This interview will aid the study. Therefore, we kindly ask the respected respondents to provide honest answers to the questions below in the structured interview/questionnaire. I assure you that the responses will be kept confidential and secure. Thank you in advance for your patience and cooperation. The questionnaire will be translated into a local language to help with understanding.

Appendix A

Questionnaire for key informants on assessing the effectiveness of agricultural mechanization service utilization. Interview prepared for smallholder farmers.

Part I. General data

Name of the respondent……………………… Country--------Region: ---------- zone-------- woreda/districts------------ kebele----------

1. What is your age range?

   ☐ Below 35 years ☐ 35-50 years ☐ Above 50 years

2. Are you the head of your household? ☐ male ☐ female

3. How many people live in your household?

   ☐ No child ☐ Below 3 people ☐ 4-6 people ☐ Above 7 people

4. What is your marital status? ☐ Single ☐ Married ☐ Divorced/Widowed/

5. What are your primary sources of income?

   ☐ Crop production ☐ Mixed farming (crops and livestock) ☐ Other business activities.

6. How would you rate the availability of labor in your area for agricultural activities?

   ☐ Highly available ☐ Moderately available ☐ Limited availability ☐ No labor availability

7. How many years of farming experience do you have?

☐ 1-10 years ☐ 11-25 years ☐ Above 25 years

8. What is your highest level of education?

☐ Illiterate ☐ Read and write ☐ formal education ☐ College/University ☐ Other----

Part 2. Landholding, Use, and Agricultural Characteristics

9. What is the total size of land you own?

☐ 0.00 - 0.25 ha ☐ 0.26 - 0.99 ha ☐ 1 - 2.5 ha ☐ 2.6 – 6 ha and above

10. What is the size of the land you use for farming?

☐ Owned land ☐ Rented-in land ☐ Share in land ☐ Rented-out land ☐ Share out land

11. How do you acquire the land you use for farming?

☐ Inherited from parents ☐ Land distribution ☐ Shared from relatives ☐ Purchased

12. Has your landholding size changed over the past few years?

☐ Decreased ☐ Increased ☐ No change ☐ Not sure

13. In which altitude zone is your land located?

☐ High altitude ☐ Mid-altitude ☐ Low altitude ☐ Not sure

14. What is your opinion on the trend of landholding size in your area?

☐ Declining ☐ Increasing ☐ Constant

15. What is the primary source of land for your household?

☐ Inherited from parents ☐ Land distribution ☐ Shared from relatives ☐ Purchased

16. Are you currently involved in cluster farming? ☐ Yes ☐ No. If yes, how has participation in cluster farming impacted your farming practices?

☐ Improved access to machinery ☐ Better access to improved seeds and fertilizers ☐ Increased productivity ☐ Better market access ☐ Enhanced knowledge-sharing and cooperation with other farmers ☐ Other (Please specify) ________________

17. How often do you receive government/professional follow-ups related to your farming activities? ☐ Frequently ☐ Occasionally ☐ Rarely ☐ Never

18. What type of landscape is found on your farm? ☐ Plain field ☐ Sloppy (irregular) field

19. What are the major crops you grow on your farm?

☐ Wheat ☐ Teff ☐ Maize ☐ Sorghum ☐ Other (Please specify) ______

Part III: General use of rental farm power and tillage operation

20. Do you use rental services for farm machinery (e.g., tractors and combine harvesters) for agricultural operations? ☐ Yes ☐ No

22. When do you mostly rent farm machinery?

☐ During peak operation periods ☐ During normal operation periods ☐ Both

23. Are you aware that service charges for rental machinery differ depending on the season?

☐ Yes ☐ No

24. Have you ever experienced delays in getting rental machinery because owners prioritized their use? ☐ Yes ☐ No

25. What type of power source do you use for the first plowing (primary tillage)?

☐ Tractor only ☐ Draught animals only ☐ Both tractor and draught animals

26. What type of power source do you use for the second plowing?

☐ Tractor only ☐ Draught animals only ☐ Both

27. Do you use harrowing (soil pulverization) after plowing? ☐ Yes ☐ No

28. If yes, what do you use for harrowing?

☐ Tractor or mechanized harrow ☐ Draught animals ☐ Manual tools

29. What method do you use for covering seeds after sowing?

☐ Manual covering ☐ Tractor (planters) ☐ Both manual and tractor

30. Are you aware of the benefits of using planters for seed covering? ☐ Yes ☐ No

31. What method do you commonly use for weed control?

☐ Manual weeding ☐ Chemical spraying ☐ Mechanized methods ☐ Manual weeding after chemical spraying

32. What method do you use for harvesting your crops?

☐ Combine harvester ☐ Manual (e.g., sickle) ☐ Both manual and combine harvester

33. Which crops do you harvest using combine harvesters? --

34. Has access to combined harvesters improved over the past few years in your area?

☐ Yes ☐ No

35. What type of grain storage facility do you use?

☐ Store in a living or animal house with a sack ☐ Store in a warehouse with a sack

☐ Use modern storage (e.g., improved "Gotera”) ☐ Use traditional storage ("Gotera")

36. Have you experienced grain losses due to poor storage conditions (e.g., mold, pests, rodents)? ☐ Yes ☐ No

37. From which of the following sources do you receive information about agricultural mechanization technologies?

☐ Media (e.g., radio, TV, internet) ☐ Development Agents (DA) ☐ Neighbours ☐ Research Centers

☐ Importers and Assemblers ☐ Others (e.g., NGOs) ______________

38. Are you aware of the presence of research and technology multipliers in your area?

☐ a) Yes, I am aware ☐ b) No, I am not aware

39. What types of challenges are faced from the table tick (√) the most appropriate response for each item? **SA**-strongly agree, **A** -agree, **U**- undecided, **D**- Disagree, **SD**- strongly disagree

No	Variable	SA	A	U	D	SD
1.	The expense of technology					
2.	Access to equipment and tools					
3.	Access to cash					
4.	Access to credit options					
5.	Familiarity with technologies					

40. What types of training are given to you? Tick (√) the most appropriate response for each item.

No	Skill Variable	SA%	A%	U%	D%	SD%
1.	Training for farmers on agricultural technology					
2.	Farmers learn about better yield-increasing technologies, like enhanced seeds.					
3.	Farmers receive training on using different tools and equipment.					
4.	Extension workers are participating in service training.					

41. Do you use any form of farm implements or machinery in your agricultural activities?

☐ Yes ☐ No

42. If No 41 is yes, please mention which farm implements or machinery you use?

- ☐ Plough and Harrow
- ☐ Planter
- ☐ Drought Power
- ☐ Sprayer
- ☐ Feed Blocker
- ☐ Weeders
- ☐ Spreader and Irrigators
- ☐ Hand Tools

43. How frequently do you use these farm implements or machinery?

☐ Always ☐ Frequently ☐ Occasionally ☐ Rarely

44. What benefits have you experienced from using agricultural mechanization?

- ☐ Enhanced agricultural production and productivity
- ☐ Increased farm returns
- ☐ Increased cropping intensity
- ☐ Reduced labor costs

45. In your opinion, what is the most significant benefit of using agricultural mechanization?

- ☐ Enhanced productivity
- ☐ Reduced labor costs
- ☐ Increased efficiency
- ☐ Other (please specify):

46. What challenges have you faced in accessing or using agricultural mechanization?

- ☐ Unavailability of agricultural mechanization centers
- ☐ Financial constraints
- ☐ Lack of knowledge about agricultural mechanization
- ☐ Poor maintenance or technical support services
- ☐ High cost of machinery or equipment

47. What is the main challenge affecting your use of mechanization?

- ☐ Unavailability of mechanization services
- ☐ Financial constraints
- ☐ Lack of technical knowledge or skills
- ☐ Inadequate maintenance services

48. Where do you access agricultural mechanization services?
- ☐ Private service providers
- ☐ Farmer unions
- ☐ Cooperatives
- ☐ Development stations
- ☐ Dealers

49. How far is your farm from the nearest road or mechanization service center?
- ☐ Less than 1 km
- ☐ 1-5 km
- ☐ 5-10 km
- ☐ More than 10 km

50. How would you rate the availability of technical support for the machinery you use?
- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor

51. How often do you experience delays in receiving technical support or maintenance services?
- ☐ Never
- ☐ Occasionally
- ☐ Frequently
- ☐ Always

52. Have you experienced frequent breakdowns of the machinery you use?
- ☐ Yes
- ☐ No

53. If yes, what type of breakdowns have you encountered?
- ☐ Mechanical issues
- ☐ Operator error
- ☐ Lack of spare parts
- ☐ Other (please specify

54. Do you have access to the following institutional services?
- Credit Services: ☐ Yes ☐ No
- Extension Services: ☐ Yes ☐ No
- Market Information: ☐ Yes ☐ No

55. How would you rate the effectiveness of these institutional services in supporting your farming activities?
- ☐ Very Effective
- ☐ Effective
- ☐ Somewhat Effective
- ☐ Not Effective

56. Overall, how satisfied are you with the use of agricultural mechanization in your farming activities?
- ☐ Very Satisfied
- ☐ Satisfied
- ☐ Neutral
- ☐ Dissatisfied

57. What suggestions do you have to improve access to agricultural mechanization in your area?

--::

APPENDIX B

Questionnaire on assessing the effectiveness of agricultural mechanization service utilization. For interviewing agricultural machinery service providers or renting the service of farm machinery.

Part I. General information

Country: -------------------- Region: ----------------- Zone: ---------------- Woreda/District: ------- kebele: -------------------- Name of respondent: ---------------------------------Sex: ------ Age: ---- Occupation: -------------- Education level: -------------------------- Status of ownership (Public, Private, Cooperative, etc.):----------------------------------

1. Are you an Agricultural Machinery Service Provider (AMSP)? ☐ Yes ☐ No
2. How long have you been providing mechanization services?

   ☐ Less than 1 year ☐ 1-3 years ☐ 3-5 years ☐ More than 5 years
3. What types of machinery do you provide for rental services?

   ☐ Tractor ☐ Combine Harvester ☐ Other (please specify): ___________________
4. What type of service do you provide?

   ☐ Ploughing ☐ Harrowing ☐ Sowing/Seed covering ☐ Weed control ☐ Harvesting

   ☐ Other (please specify): _________________________
5. Do you face challenges in providing timely mechanization services? ☐ Yes ☐ No
6. What are the main reasons for delays or challenges in providing services?

   ☐ Shortage of machinery ☐ Lack of skilled operators ☐ Lack of road access

   ☐ High operational costs ☐ Land fragmentation ☐ Poor weather conditions

   ☐ Other (please specify): _________________________
7. How would you rate the availability of agricultural machinery in your area?

   ☐ Very poor ☐ Poor ☐ Satisfactory ☐ Good
8. Are you able to meet the demand for mechanization services during peak times (e.g., planting, harvesting)? ☐ Yes ☐ No

9. Please rate the following factors that constrain your ability to deliver mechanization services:

Factor	Very Poor	Poor	Satisfactory	Good
Workplace setting				
Access to roads for operations				
Presence of skilled operators				
Presence of skilled mechanics				
Availability of farm machinery				
Government support				
Availability of spare parts				

10. How would you rate the financial challenges of running a machinery service business?

☐ Very poor ☐ Poor ☐ Satisfactory ☐ Good

11. Do you face difficulties in purchasing machinery due to financial constraints or lack of access to credit? ☐ Yes ☐ No

12. Have you ever received any financial assistance or support to improve your mechanization services? ☐ Yes ☐ No

If yes, please specify the source of support: _________________________

13. How often do smallholder farmers in your area use your services?

☐ Regularly ☐ Occasionally ☐ Rarely ☐ Never

14. What is the most commonly requested service?

☐ Ploughing ☐ Harrowing ☐ Sowing/Seed covering ☐ Weed control ☐ Harvesting

15. What factors do farmers consider when choosing mechanization services?

☐ Cost of service ☐ Availability of machinery ☐ Availability of operators

☐ Timeliness of service ☐ Quality of work ☐ Distance from farm to service provider

☐ Other (please specify): _________________________

16. Do you face any seasonal variation in demand for mechanization services? ☐ Yes ☐ No

If yes, during which season(s) is the demand highest?

☐ Rainy season ☐ Harvest season ☐ Both

17. What are the major challenges you face in running your machinery service business?

☐ High operational costs ☐ Lack of skilled operators and mechanics ☐ Unavailability of spare parts ☐ Poor infrastructure (e.g., roads) ☐ Fragmented land ☐ Weather conditions ☐ Other (please specify): _________________________

18. What improvements or support would help improve your ability to provide mechanization services?

☐ Access to affordable credit ☐ Availability of skilled operators and mechanics

☐ Improvement of road infrastructure ☐ Lower cost of machinery

☐ More government support ☐ Access to spare parts

☐ Other (please specify): ______

19. Are there any opportunities for expanding your mechanization services in the future?

☐ Yes ☐ No

If yes, what steps would you take to expand? ---

20. What payment method do you use for your mechanization services?

☐ Cash ☐ Credit ☐ Barter/Trade ☐ Other (please specify): _________________

21. Do you think the payment terms are fair for both you and the farmers? ☐ Yes ☐ No

22. If you believe the payment terms are unfair, please provide your reasons: --------------------

----

23. What additional comments or suggestions do you have regarding the improvement of agricultural mechanization services in your area?

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APPENDIX C

Questionnaire on assessing the effectiveness of agricultural mechanization service utilization. For interviewing Shashemene, Arsi Negele, and Siraro Woreda Agricultural Office.

Part I. General information

Country: --------------- Region: ------------- Zone: -------------Woreda/District: ------- kebele: ----

Respondent's name: --------------------------------Gender: ------ Age: --------------------

Job: ---------------Level of education: --------------------------------------

1. How is agricultural mechanization currently performing in your woreda?

…………………………………………………………………………………………………

2. How do agricultural mechanization practices contribute to boosting the productivity of smallholder farmers in your woreda?

…………………………………………………………………………………………………

3. What kinds of agricultural mechanization services are available in your District, and which ones do you recommend for smallholder farmers? Why?

…………………………………………………………………………………………………

4. What possibilities are there for enhancing agricultural mechanization practices for smallholder farmers?

…………………………………………………………………………………………………

5. What are the key obstacles preventing agricultural mechanization practices among smallholder farmers in your District?

…………………………………………………………………………………………………

6. How can smallholder farmers obtain agricultural mechanization services?

…………………………………………………………………………………………………

7. What is the role of the government (your office) in improving the livelihoods of smallholder farmers through agricultural mechanization services?

…………………………………………………………………………………………………

8. What challenges are faced in promoting, supplying, and using mechanization technologies in the woreda?

…………………………………………………………………………………………………

9. How is the situation of the woreda agricultural extension staff in terms of supporting agricultural mechanization (qualifications and number of staff)?

……

10. Is there any training or capacity building provided to farmers to assist with agricultural mechanization?

…………………………………..………………...

11. What are the opportunities for agricultural mechanization in the woreda (land suitability, availability or scarcity of labor, and marketable crops)?

……

12. Please put a tick mark (√) in the appropriate box to show your level of agreement

Constraints	Very poor	Poor	Satisfactory	Good
Workplace setting				
Access to roads for operations				
Presence of skilled operators				
Presence of skilled mechanics				
Support from the government				
Spare parts	Private shop ☐		Government ☐	

13. What are the advantages and disadvantages of using machinery in agriculture for smallholder farmers in your area?

Strength………………………………………………………………………………………

Weakness………………………………………………………………………………………

Suggestions…………………………………………………………………………….

Any comments on the subject………………………………………………………….