EVALUATION OF STATUS OF FOUR-WHEEL SMALL CAPACITY TRACTORS IN OROMIA REGION: THE CASE OF ODABULTUM, MI'ESSO AND ADA'A DISTRICTS

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Agricultural Machinery Engineering

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ADVISOR APPROVAL SHEET

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Evaluation of the status of four-wheel small capacity tractors in Oromia region: the case of Oda Bultum, Miesso, and Ada'a districts" prepared under my guidance by Tsegaye Mulu Jember submitted in partial fulfillment of the requirement for the degree of Masters of Science in Agricultural Machinery Engineering. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedure.

Dr. Ing Simie Tola	_____	Feruary, 2022
Name of advisor	Signature	Date

DECLARATION

I, hereby declare that this Master's thesis which is entitled “Evaluation of the status of four-wheel small capacity tractors in Oromia region: the case of Oda Bultum, Miesso, and Ada’a districts” 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 sources of materials that are used for this thesis have been duly acknowledged through citation.

Tsegaye Mulu Jember	_____	February, 2022
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This MSc Thesis has been submitted for examination with my approval as a thesis advisor.

Dr.Ing Simie Tola	_____	February, 2022
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I, the advisor of this thesis which is entitled "Evaluation of the status of four-wheel small capacity tractors in Oromia region: the case of Oda Bultum, Miesso and Ada'a districts" and developed by Tsegaye Mulu Jember hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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ACRONYMS

ANOVA	Analysis of Variance
ASAE	American Society of Agricultural Engineering
ASABE	American Society of Agricultural and Biological Engineering
ECRA	Ethiopian Custom and Revenue Authority
EIAR	Ethiopia Institute of Agricultural Research
FAO	Food and Agricultural Organization
FGD	Focus Group Discussions
FDRE	Federal Democratic Republics of Ethiopia
GDP	Growth Development Plan
METEC	Metals and Engineering Corporation
UNIDO	United Nation for Developmental Organization
SDPRP	Sustainable Development and Poverty Reduction Program
SSAP	Support to Sustainable Agricultural Productivity

ABSTRACT

Agricultural mechanization deals with the design, utilization and management of technical systems and processes of engineering for the production, storage, treatment, and processing of agricultural goods. In Ethiopia, agricultural mechanization is being encouraged to boost agricultural production. However, different types of machines dropped and many of them became scrap. Some of the machineries are failing frequently. Based on these problems the study aimed to investigate utilization, effectiveness, constraints, opportunities and status of four-wheel small capacity tractors in Oromia region specifically in Oda Bultuum, Mi'essoo and Ada'a districts was worked. The structured questionnaires were addressed to 352 respondents of non-users and 45 respondents of four-wheel small capacity owners. Both purposive and random sampling techniques were employed which are dis aggregated based on education level, agricultural ecology, soil type and way of life existence. Data collection methods included structured interviews, focus group discussions, structured questionnaires and field tests. SPSS and excel software packages were used to analysis the collected data to useful information. Comparison were made in utilization and status of machineries on the bases of district. the findings showed that machinery status, utilization of targeted tractors, trainings given and operating skills are more effectively implemented in Ada'a district than the two districts. the result indicates Durability of tractors are more related with the closer availability of facilities for machinery management service. (61.5%) of the operators in Ada'a district are good in operating the machineries and (38.5%) have gotten trainings in operation and maintenance services. There was a significant difference between farmers' interest and educational level, perception of respondents about the capability of targeted tractors with ($p<0.05$). According to our investigation it is important to recommend that the study on constraints, challenges, soil type, type of tractor and implement to be used shall be studied before distribution of four-wheel small capacity tractors to the end-users.

Keywords: utilization, factors, exploitation, four-wheel small capacity tractors, after sales service, effectiveness

CHAPTER ONE

1 INTRODUCTION

1.1. Background and Justifications

The Ethiopian government has adopted agricultural-led industrialization as the central plank of its development program, with a focus on the growth of productivity in the sector. A study reported the benefits of more production and productivity from increased farm power/energy (Singh, 2006). Apart from improved crop yield, the increased usage of farm power for cultivation creates further demand for related agricultural machinery for harvesting, storage, and adding value to primary products and so generates employment opportunities and income potential along the value chain (Sims, et al., 2017). Stout (2000) stated that to ensure an adequate and safe food supply for expanding world population tractor is the prime source of power in agricultural mechanization in the developing countries.

Based on the reviews done in the area of mechanization and direct observation of the targeted areas availability, reliability, effectiveness, durability, and accessibility of four-wheel small capacity tractors have their contribution in developing an agricultural sector and the country at large. Different private and governmental companies have been supplying different types of machinery and equipment for end-users such as governmental farm industries, private farm projects, and farmers. Even though the availability of four-wheel small capacity tractors is inevitably important in improving the productivity of agricultural farming practices, evaluation of their performance is more important to claim their reliability. Distribution without studying the interest of end-users, low understanding about the necessity of performance evaluation, lack of aftersales service, unconfirmed information's about the performance distributed in the farmers, and unavailability of trained and concerned personnel in the sector are major reasons for the reduction of demand in using small horse power tractors resulting in the problem of food insufficiency.

EIAR, (2017) study indicates that from 14.7 million households, 8.82 million subsides on less than 1 hectare of land and 0.147 million farmers own land greater than 4 hectares The number of tractors imported into the country from 2011 to 2014 March according to the data from the Ethiopian Custom and Revenue Authority (ECRA) is around 12, 231. According to the data from Adama tractor factory 3000 tractors imported before 2004 as they have reached their end of service life

and considering 60%-70% of the tractors imported after 2010 to be out in the field, about 10,000-11,000 tractors currently could be found in the Ethiopian farmlands. Under agricultural mechanization, field machines such as tractors constitute a major portion of the total cost of crop production. The proper operation of these machines is essential for profitable agricultural production. Therefore, performance data for tractors and implements under different soil conditions are important for farmers, machinery operators, and tractor manufacturers' alike (AlSuhaibani et al., 2010).

Information gathered from the Ministry of Agriculture revealed that four-wheel small capacity tractors and respective implements have been in progress of assembling, distribution and utilizing by two companies in Ethiopia these companies are Ethio-Engineering Group and HiTech trading house deals with different types of machinery e.g. tractors, combine harvester, sprayers and different farming implements. On the behalf of Ethio Engineering Group, the company has assembled more than 14000 tractors among these total of 7000 are sold and 6500 are small capacity tractors and 3000 are sold, whereas in the case of HiTec trading house it has imported more than 6 tractors and 10 implements.

The local importer, manufacturer, and dealer represent the agricultural mechanization in private sector. Data from the ministry of agriculture underlines in Ethiopia there are around 13 importers/manufacturers/dealers involved in the agriculture machinery business among this HiTech trading house and the engineering group has imported more than 6500 four-wheel small capacity tractors from 2011 to 2012 fiscal years. other importers WGT, Kaleb service, METEC (Ethio-Engineering Group), Ries Engineering, Gedeb Engineering PLC, Adeb Engineering PLC, Moenco PVT, Hagbes LTD, AETS, Amio Engineering. Whereas Captain, Massey Ferguson, Belarus, Landini, Class, SAME, Johndeer, and Case are some brands that are available in Ethiopian agricultural machinery market.

The former Nazareth Tractor Factory now called the Adama Agricultural Machinery Industry operating under the Metals and Engineering Corporation (METEC) is the other important enterprise, which imports and assembles tractors like Belarus and other Chinese brands ranging from walking tractors of 8 hp to four-wheel tractors in the 300hp range. The other important actor who is active in importation, manufacturing, after-sales services is Agricultural Equipment and Technical Service Share Company.

Four-wheel small capacity tractors play an important role in improving the daily farming practices of farmers especially those who own small land. Parameters such as affordability in cost, easy operability, productive output, and easiness of maintenance make them more effective for our farmers. Therefore, investigating how these impacts are affected could be required to be addressed problems relating to the root Couse of machinery utilization reduction and exploitation of these machines.

Utilization of four-wheel small capacity tractors that are in the hand of end-users are not studied well. Accordingly, the performance evaluation and assessment of the status is expected to be done as far as the importance of these machines is crucial in the improvement of agricultural productivity. Many four-wheel small capacity tractors are put as wastes in the farmer's farmland. These problems need immense attention; therefore, the research was designed to find basic solutions by preparing questionnaires on how farmers perceive the productivity and capability of selected tractors with their respective implements. This can address and open a way to research further in adopting and using tractors with immense pre-distribution studies.

1.2. Statement of the Problem

Under the federal government of Ethiopia Ministry of Agriculture is striving in agricultural mechanization development, for this approach agricultural machineries are imported with free off custom payments. This has facilitated introduction of new agricultural mechanization technologies and improved access to the mechanization technology service provision. Using this opportunity governmental and private company of agricultural machinery importers, assembling factories and machinery dealers were distributing different sized four-wheel small capacity tractors throughout the country. Adama Tractor Factory, from the distributors, has distributed more than 3000 four-wheel small capacity tractors. This has been considered to transform the traditional farming practice.

However, distributed four-wheel small capacity tractors are not utilized properly because spare parts are not available, training were not delivered to the end-users. Machinery management skills are not implemented, pre-distribution assessment studies were not conducted, dealers and distributors didn't take responsibility in handling tractors and the inappropriate selection of distribution areas where the selected tractors can't operate properly due to topography and soil

type. In addition to these, the fragmented and very limited land holdings of the farmers is the other major problem standing against the targeted tractor distribution and utilization. All the above mentioned challenges have resulted in devastating and hindering the proper utilization that affects the status of tractors.

These problems need immense attention; therefore, the research was designed to find basic solutions on factors influencing the interest of farmers to use tractors, knowing the status of the existing tractors, and to test the performance of the available tractors in sandy loam soil type. This can address and open a way to research further in adopting and evaluating the performance of four-wheel small capacity tractors in Ada'a wereda, Mi'esso wereda and Oda Bultum wereda.

1.3. Objectives

1.3.1. Major Objective

The major objective of the research was to evaluate the status of four-wheel small capacity tractors in selected areas of Ada'a wereda Bishoftu area, Oda Bultum wereda, and Mi'esso districts in Oromia regional state.

1.3.2. Specific objectives

1, To provide an overview of the status of four-wheel small capacity tractors in the targeted study areas.

2, To assess, constraints and factors affecting adoption of four-wheel small capacity tractors in the study areas by showing solution approaches.

3, To conduct assessment on utilization and exploitation of four-wheel small capacity tractors in the focused areas.

4, To recommend important requirements and needs to improve adoption of the targeted tractors

1.3.3. Research questions

(1 What is the current situation of four-wheel small capacity tractors in the selected areas?

(2) What is the perception of farmers in using four-wheel small capacity tractors and agricultural practices?

(3) What are the challenges that affect the utilization of four-wheel small capacity tractors and how can they be approached?

1.4. Significance of the Study

Proper use of agricultural machineries and equipment's are the primary activities that should be taken in to account at the very beginning of farming investment or subsidy. The productivity can be improved by keeping the machinery on optimum condition, selecting good maintenance, reducing idle time and making more effective use of available machinery and its capacity. Accordingly, the major significance of the study includes:

- ✓ To motivate further studies on four-wheel small capacity tractors especially those who are researchers, designers, importers, distributers, dealers generally governmental and private stakeholders who are actors in agricultural machinery sectors.
- ✓ To provide researchers with access to the findings of this study so that they can utilize them as a guide in further studies to distribute, evaluate effectiveness or adoption.
- ✓ As a guide for further study on the perception of farmers in using four-wheel small capacity tractors and assessing the interest of farmers in the study areas.
- ✓ To open a channel of research in the development of four-wheel small capacity tractors. Generally, the significance of the study was to indicate conditions, services, the status and safeties that can be implemented to effectively utilize the targeted tractors in the study areas.

1.5. Scope of the Research

The scope of this research was limited on assessing the perception of farmers, evaluating the effectiveness and status of available four-wheel small capacity tractors in Oda Bultum, Mi'eso and Ada'a weredas. The evaluation considered factors such as land holdings, demographic factors, educational status, utilization and other factors through structured questionnaires, interviews, field observation and focus group discussions. The boundary of problems to be investigated included assessing effectiveness, utilization, exploitation and constraints affecting the status of four-wheel small capacity tractors.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. The Need for Farm Machinery

Power source in agricultural farm is one the determining factors for the level of agricultural development and stage of mechanization. Agricultural mechanization is often contributing most to increase agricultural and can be defined as any agricultural means that can be employed in the process of agricultural production.

The profitability of mechanization is dependent on land and labor availability. (Stroh de Martinez et al., 2016) state that mechanization is most profitable in areas where land is abundant and labor scarce. This seems not to apply for Ethiopia however, as the rise in primarily young men migrating to cities has led to an increasing number of households suffering from labor shortages which mainly impact children and women (Sims, 2017).

Nevertheless, the rationale for engine-driven mechanization in Ethiopia is to increase the timeliness of operations, to facilitate the efficient use of inputs, to increase labor productivity, and thereby increase the productivity and income of farmers and other rural stakeholders.
It is also believed that it can reduce the workload for women and improve the situation of women headed households. This should ultimately lead to more sustainable production systems (Duerr et al., 2016; Martinez et al., 2016). Four-wheel small capacity farm machinery is the equipment that farmers use to till, plant, cultivate, and harvest, including tractors, plows, discs, planters, and combines (Omer 2013).

2.1.1. Types of agricultural machinery

Tillage implements should prepare a satisfactory seedbed while conserving moisture, destroying early weed growth, and minimizing erosion potential. Planters and seeders should provide consistent seed placement and population as well as properly apply pesticides and fertilizers.
Harvesting equipment must harvest clean, undamaged grain while minimizing field losses.

The performance of a machine often depends on the skill of the operator, or weather and soil conditions. Nevertheless, differences among machines can be evaluated through field trials, research reports, and personal experience.

The selection of power matching with machines is one of the most important decision parameters of agricultural mechanization accessibility and performance evaluation. Many factors are affecting the selection such as agricultural conditions, farming requirements of soil and crops, technological knowledge, and economic condition (Depney et al., 1983).

Disc implements as mentioned by Bates (1963); Deere and Company (1976), are of particular use in hard, dry soils, where penetration by moldboards would be difficult and where hidden rocks or stumps might cause serious damage to moldboard.

Harrows are designed as secondary tillage implements. Nevertheless, the use of the offset disc harrow has been and still is, for primary tillage (Kepner et al., 1982). The offset disc harrow according to Bashir (1996) performed the function of a plow and a cultivator under conditions neither of these implements would perform satisfactorily.

The effectiveness of deep tillage varies from soil to soil, from place to place, and from year to year, but the need for deep tillage has been questionable for more than 50 years (Yang and Quintero, 1986). The difficulty of selecting the most effective implements for a particular circumstance is evident from the wide variation in the number of cultivation operations carried out by different growers under the same conditions

2.1.2. Small-scale mechanization with oxen

Given the high significance of oxen-power this section describes the current system and its impact on social, socio-economic and environmental parameters, and explores the attempts to improve technology and management. Traditional soil preparation in Ethiopia requires three elements: the operator, a pair of oxen and the tillage implement (Asfaw, & Ayele, 2001).

Farmers use the *maresha* to create a fine seed bed, to suppress weeds and to increase water infiltration (Araya, Nyssen, Govaerts, Baudron, et al., 2016). In its construction form the *maresha* is a beam plough, similar in its development to those in other parts of the world (Hopfen, 1981).

In addition to the afore-mentioned economic problems the necessary repeated passes of cross-ploughing when working with the *maresha* causes soil degradation through erosion, soil organic carbon loss, compaction and crusting (Gebregziabher et al., 2016). In a maize trial in the rift-valley it was shown that long-term *maresha* ploughing leads to higher crop susceptibility to droughts and dry-spells (Abdul Kedir, & Sterk, 2011). In Ethiopia, over 90% of farmers are small holders having only one hectare or less. They perform tillage by animal drawn plow system. Using this system, the plowing depth ranges from 10.1–15.3 cm and the oxen travel at speeds of 0.3–0.5 m/s (Goe, 1999). Small holders contribute 95% of the annual cereal production of the country. Most of the active labor (80 to 85%) is engaged in this sector and more than 15 million rural farm families' livelihood depend directly on agriculture (ATA annual report, 2018). Out of the entire population, 30% is below the national poverty line and 48% of this headcount is from smallholder farmers. Instead of off-farm jobs, most smallholders rely on crop production and livestock income. In 2015, FAO reported that the daily income of smallholders as USD 0.8 per person (FAO, 2015).

2.1.3. Small capacity agricultural machineries

Small horse power agricultural machinery plays an important role in improving performance, productivity, and reducing costs of agricultural operations. During the recent decades, agricultural machines have been developed to reduce labor costs as well as improve the timeliness of field operations (Schafer-Landefeld et al., 2004). Moreover, agricultural machine efficiencies have a significant effect on the yield which in turn impact the overall cost of production (Pitla et al., 2014).

The use and introduction of four-wheel small capacity tractors has a crucial importance in alleviating life challenges for farmers. The development and distribution has its own impact in the farming industries but technical evaluation of their performance is not critically well assessed this will result in devastation of the economy. an increment of agricultural productivity is the function of different factors which should be well controlled otherwise they will result in machine depreciation and economical loss.

2.2. Status of agricultural mechanization in Ethiopia

Despite the long history of agriculture in Ethiopia and the start of using some sort of mechanization, still, the country's agriculture is characterized by the use of traditional farming implements and

practices with very low energy inputs. The entire field operations at small-scale agriculture are performed with very simple farm tools with mainly human and animal power sources.

In recent years, the use of tractor farm technology is increasingly becoming important among the smallholder farmers at the expense of drought animals. While in the early 1970s only 4% of total smallholder farming households used tractors for plowing, this figure rose dramatically to 17% and 39%, respectively, by 1980 and 1990s.

Even though the status and the quantity of tractors and agricultural machinery are the progress of improvement but their performance is not well considered and evaluated yet in Ethiopia, which requires more researches to save the wastage of resources in the mechanization sector.

Tractor imports have rapidly increased in the past decade, but slowed down recently, whereas the import of combine harvesters is steadily increasing. The Figure below the report from the agricultural transformation agency shows the changes in agricultural machine imports between 2001 and 2014.

Duerr et al. (2016) conducted a study within the scope of the GIZ project Support to Sustainable Agricultural Productivity in Ethiopia (SSAP). Calculations for different agricultural mechanization technology levels including all relevant tractor field operations, like plowing, harrowing, seeding and fertilizer as well pesticide application. The four levels ranged from 80-100 hp tractors with more simple implements (disc plow and disc harrow) to 125-150 hp capacity tractors with more advanced implements for combined operations (moldboard plow, power harrow with seed drill).

2.3. Small scale mechanization in Ethiopia

This section looks at the rationale for promoting small-scale mechanization in Ethiopia and current examples of small mechanization in some areas. The rationale of national politics and international development aid to promote (large-scale) mechanization is mainly to increase the outputs per area of land. Duerr et al. (2016) suggest that there are four key drivers in the production increase through mechanization:

(1) More efficient use of labor,

(2) Timeliness of operation,

(3) More efficient use of inputs,

(4) More sustainable production systems. They estimate that through the mechanization of all farm operations yields can increase by 80% from the currently available product. Several efforts to introduce tractors to Ethiopia have been made in the past. State-owned hiring schemes that were running between 1970 and 1990 collapsed due to the financial burden (International Maize and Wheat Improvement Center, 2014).

Recently, the agricultural transformation agency and ministry of agriculture of Ethiopia in collaboration are developing an Agricultural Mechanization Strategy based on the experience of different countries. It has been reported by the government that only 5.5% of the total farmers found throughout the country have plowing machines, out of these, the smallholder farmers exclusively own only 22%. In other words, the percentage of farmers owning plowing machines out of the total smallholder farmers is 1.21% (ATA Report, 2015). Currently, there is only 0.3877kW of farm power per hectare. This farm power is obtained from current labor available from oxen at 13 million head (87%) and 12,500 tractors (13%) (Agricultural Transformation, 2014). A major reason behind the problems faced by the Ethiopian agricultural mechanization is the small and fragmented land holdings, which make use of technology prohibitively expensive and not very beneficial for small and marginal farmers.

Four-wheel small capacity tractors are most significant in different areas of Oromia regional state. Since most of them are distributed on large scale due to the combination of various favorable factors. The area is flat in many parts, stone free, and has a high percentage of commercial farms (<2.5 ha) as well as smallholder farms with relatively small farm sizes. Finally, labor prices in the region are comparatively high and the rain patterns allow for a second short season that requires relatively fast harvest and land preparation.

2.4. Past Mechanization Efforts

According to FAO (1995), past efforts of various African governments and donors to accelerate the use of mechanization, inputs have produced mixed results. Compared with other regions, Africa has not had the large-scale investment in agricultural infrastructures, such as irrigation, or other inputs needed to intensify crop production. This is partly because Africa is fragmented into relatively small farming regions. Investment in mechanization has been limited to large commercial farms or government schemes. In many cases where governments established tractor hire schemes to serve small-scale farmers, planning was very short term and management was

poorly trained and poorly supported. Such schemes, although relatively few across the continent, failed miserably, denting the image of agricultural mechanization in general.

2.5. Selection of Four-Wheel Small Capacity Tractors and Implements

Tractors are the primary source to provide a mechanical power to farms and fields (Kepner et al., 1982). McNeill stated that tractor performance will be studied over the following times optimum results could be obtained for different agricultural machinery (McNeill et al., 2008). This has its own implication for the future researches in the area. It is always desired to have the most power converted from the engine to traction power which results in lower energy loss during the agricultural operation (Ahaneku et al., 2011). Improper selection of tractor size can cause excessive operating costs. So, knowing the parameters that affecting efficiency would improve the performance of agricultural machinery. Moreover, despite the type of soil condition, and tire design, other important parameters that affect the tractor performance include implement size, practical speed, and depth of operation. these parameters can be easily being managed and controlled by the operators to obtain the optimum performance.

According to Hunt (1979), stated that the effectiveness, with which power is applied to accomplish the farm production objectives, is the sound of machine economic performance. According to Culpin (1975), stated that the power performed in the field may be determined by types and number of tractors needed; tractor sizes; tractor utilization (average annual use); seasonal pattern of use; annual use and cost of operation.

2.6. Farm Machinery Work Rate

According to Liljedahl *et al*. (1979) cited that, the greatest single factor affecting the hourly cost of machinery operation is the use per year. It is better to use a machine as long as possible, but too much use will negatively affect the performance of the machine.

The following time fractions to be considered when computing the capacities or costs of the machinery. These are machine preparation time, travel time to and from the field, machine preparation time in the field before and after the operation, theoretical field time, turning time and time to load or unload the machine, machine adjustment time, maintenance repair time, and operator's personnel time. Not all the above time elements are commonly charged against machine operations. The operator's personnel time, machine preparation time are highly variable quantities and are usually unrelated to the operating efficiency of the machine (Hunt, 2001).

Hana (2016), suggested the following equations for theoretical field capacity calculation which can be used to evaluate work rate:

$$TFC = \frac{s \times w}{c} \quad \text{(2.1)}$$

Where: TFC - Theoretical field capacity (ha/hr).

S - Speed (km/hr).

W - Rate width of the implement (m).

C – Constant (10).

$$EFC = \frac{FE \times S \times W}{C} \quad \text{(2.2)}$$

Where: EFC = Effective field capacity (ha/hr).

FE = Effective field efficiency, decimal.

S - Speed (km/hr).

W - Rate width of the implement (m).

C - Constant (10).

According to Siemens and Bowers (1999), there are several important reasons why a machine may have built into the operation. Some lost time factors are dominated by good planning and management, and typically factors causing lost time include: unused capacity, filling procedures, turning and field conditions, unclogging machines, making adjustments, reducing breakdowns, servicing machines, rest stops, checking machine performance and unmatched machine capacity.

Table 1. General variation of field efficiency

Operation	Field efficiency
Tillage	(77-90)%
Disc harrow, disc plough	(75-85)%

2.7. Power Requirements

According to Edwards *et al*., (2001), mentioned that the horsepower needed to pull a certain implement depends on the width of the implement, draft requirement, and soil conditions. They suggest the following formula for estimating the required horsepower measured at the brake power. Tractors are often rated by brake power or PTO power rather than drawbar power (Ajit *et al*, 2006).

After the drawbar power is calculated, the PTO power and/or net flywheel power can be estimated using equation 2.3 as follows:

$$PTO = \frac{\mathrm{S} \times \mathrm{W} \times \mathrm{D} \times \mathrm{Sd}}{3.6} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. 2.3$$

Where: S-Speed KM/HR

W-width of implement. M

D- draft KN/M

Sd- soil factor

Table 2. Soil factor taken from ASAE (2003) standard

Type of soil	Soil factor
Tilled	1.8
Firm	1.5
Sandy or soft soil	2.1

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Study Area Descriptions

The research for this thesis was conducted between April to July and September to November for the second phase of 2021 in west Harerghe Mi'esso and Oda Bultum districts and east Shoa Ada'a districts in Oromia regional state Ethiopia. Farm visits, in Joy Tech Farms PLC, Melkassa Research Center and some model farmers' farm land provided us first insights into farming systems, the status and issues surrounding mechanization using four-wheel small capacity tractors then after on we have been engaged to do the task.

Oda Bultum wereda: is one of the districts in west harerghe that is located 37km away from ciroo town the capital city of the zone and 337km away from Adiss Ababa. The center of the district is Dedessa city. Both black and red clay soils are dominant in the area. There are about 35,000 farmers house hold. In the district 20,870 ha of land is arable for farming from this 18,000 ha is suitable for mechanization. the dominant crop types of the district include: maize, sorghum and teff. annual temperature is 18^{o} c to 22^{o}c, annual rainfall ranges from 900 to 1,800mm and the height above sea level 1200-2400 meter above sea level. There are 11 four-wheel small capacity tractors and 5 tractors are working seasonally. These tractors are distributed in kebeles of burqa, gossesso and cinqo

As a zone west Harerghe has 275, 000 ha arable land and from this about 60% is suitable for mechanization. Accordingly, Mi'esso wereda has more than 15,430 ha arable and more than 11,000 ha suitable for mechanization and it is located 25km from Ciro and 300km away from Adiss Ababa. the height of the area above sea level is about 1350m, annual rain falls ranges from 700 to 2500mm and average annual temperature is 32^{o}c. there are 31 kebeles from theses kebeles Gorbo, Odabla and Miesso are the main areas where more than 25 four- wheel small horse power tractors are found and about 6 aren't working, 5 are working and 14 tractors requires urgent maintenance. The soil profile of Mi'esso district is black clay soil relatively easy for the operation of four-wheel small capacity tractors than Oda Bultum wereda. The common crop types in the area includes sorghum, maize and wheat.

Ada'a wereda bishoftu area: is located near the capital city of Ethiopia and the soil profile is 62% black clay soil. The area is found at 2800m above sea level and the common range of temperature is between 28^{o}c to 32^{o}c. The district is potential producer of cereal crops in Oromia National Regional State and in Ethiopia in general. The topography of the Kebeles is most probably plain. In the study area, mixed farming practice, crop production and livestock rearing is common and supplementary irrigation practice is used during dry season. The common dominant crops grown in the area are teff, wheat, vegetables, fruits, chick pea, lentils and other commercial crops.

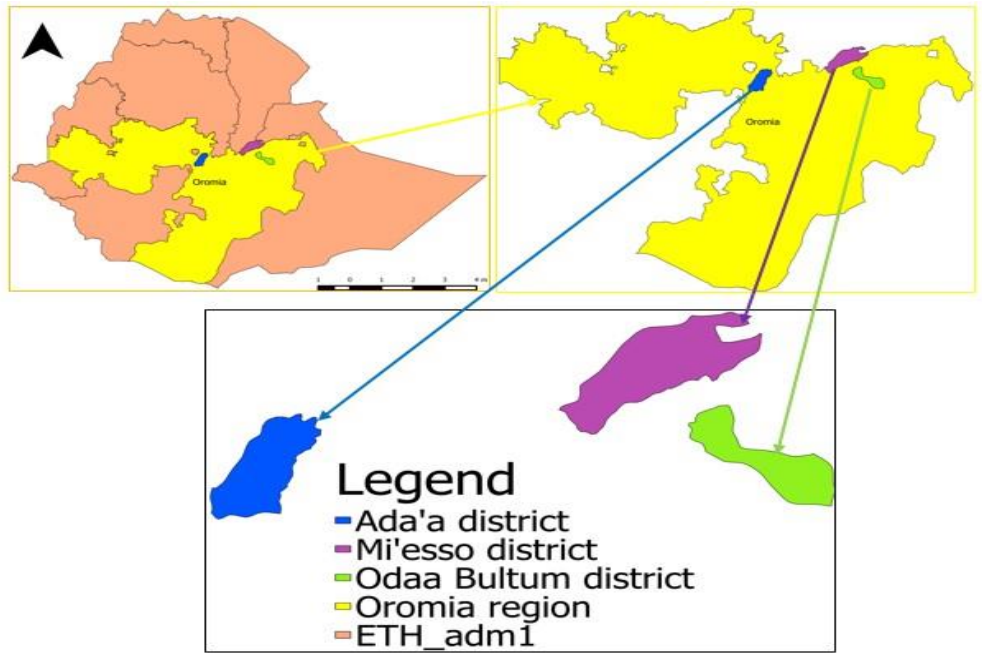


Figure 1. Map of the study areas

3.2. Method of Data Collection

To provide insights before main sampling, discussions were made with district experts from the respective district office of Agriculture to make clear the purpose of the study and seek their assistance. Two stages sampling technique were made by selection of districts at the first stage followed by selection of Kebeles. A proportional random sampling technique was used to identify the respondents to be selected for the study.

During the exploratory survey, discussion was held with experts at kebele level working in the area to collect relevant information on major aspects of mechanized farming intervention. The questionnaires were designed to collect both qualitative and quantitative data. It included

respondent characteristics, livestock ownership, description of ploughing practices and past experience in relation to mechanized agriculture. The questionnaires were pre-tested for its validity before the actual survey was conducted. This is mainly by experts and with supervision of main investigators on the field. As a result, some questions were modified. Moreover, focus group discussion was conducted in the three districts to supplement the data obtained during the main survey and arguments of the results. We were not, however, able to obtain data on costs and prices, which greatly handicapped the economic analysis. Both primary and secondary data were collected from the sample

3.2.1. Farm survey

In all sites, the heads 397 respondents were interviewed in 2021, using a standardized semi structured questionnaire that addressed economic composition, utilization of small horse power tractors, constraints in using and opportunity to own small horse power tractors. Input, output, and labor use for adopting tractors were collected for the three main operations in terms of area of the farming household. Questionnaires were administered only when express consent was granted. Households were selected using a systematic sampling procedure in study villages based on representative transect routes across the village in which every model farmer, on alternate sides of the track, was sampled. In case one of the selected households was not available, the next one was selected. This is a type of probability sampling, in which a random starting point was chosen on all transect routes.

3.2.2. Focus group discussion

Parallel focus group discussions (FGDs) were organized in each site: one with proportionating the average number male and female participants. The main theme was the source and level of drudgery in farm chores and the perceptions of farmers in using four-wheel small horse power tractors by briefing the profit. The FGD involved bringing in small groups of informed men (typically 6 per session) at locations identified and agreed upon by the participants.

3.2.3. Interviews:

Subsector studies on agricultural mechanization in Ethiopia are largely unavailable. Hence, quantitative information on various numbers of machinery were collected from limited secondary

data and triangulated with the information from farmers, importers, dealers and manufacturers**.** checklist was designed and used to interview the various actors that cover all the component of the subsector. One to one and key informant interviews, (focus group discussion) were used to understand and learn about the sector in line with the overall objective of the study. A personal interview was conducted with the farm operators and farm managers.

Data such as primary data were collected from the selected sample respondents with structured questionnaires, key informants and focus group discussions and secondary data were collected from internet, bureaus, offices and literatures through document reading in the study areas.

Questions were asked about an acceptance and awareness of utilizing four-wheel small capacity tractors. The Field data's; include the size of the field, soil type, climatic condition, model, type, capacity and status of tractor and availability of infrastructures.

3.3. Research Design

The questionnaires were designed to collect both qualitative and quantitative data. It included household characteristics, livestock ownership, description of ploughing practices and past experience in relation to mechanized agriculture. The questionnaire was pre-tested for its validity before the actual survey was conducted. This is mainly by experts and with supervision of main investigators on the field as a result, some questions were modified. Moreover, focus group discussion was conducted in the three districts to supplement the data obtained during the main survey and arguments of the results.

Secondary data on socio-economic characteristics of the study area, soil type, demographic characteristics, major crops grown, and other issues were collected from published and unpublished documents and reports of organizations. The methodology that was employed in the study were both qualitative and quantitative, involving the collection of data using a structured questionnaire. The current utilization and exploitation of tractors were studied by gathering information from end users, distributers, dealers, private companies and governmental stakeholders through questionnaires, interviews and field observation.

The study was implemented to assess and evaluate the status and effectiveness of four-wheel small capacity tractors. From the side of farmers, we have gathered data about the socio-economic affairs, demographic status, the natural and artificial factors influencing adoption of four-wheel

small capacity tractors. Whereas from other actors in the sector we have investigated data about the availability of spare parts (after sales service), the status of distribution, previous obstacles faced in adoption and future solutions for the enhanced utilization of the targeted tractors. The physical observation was also made on the current existing activities performed by four-wheel small capacity tractors and information were gathered from the agricultural beauros. Generally, we have used inclusive and targeted processes which can address the raised problem by differentiating the factors affecting the utilization, adoption and effectiveness of four-wheel small capacity tractors in the study area.

The utilization and exploitation of available four-wheel small capacity tractors were assessed through gathering answers of structured questionnaires like operating skill of owners, availability of after sales service, the trend of performance evaluation while starting to use, status and durability of machines, skill operating tractors, service life of tractors, common defects most frequently happened and socio-economic status of the users.

3.4. Sample Size Determination

A two stages sampling technique was made by selecting districts at the first stage followed by selection of Kebeles. A proportional random sampling technique was used to identify the respondents to be selected for the study.

The determination of the sample size follows Slovin's (1960) formula used to calculate sample size when little information is available for the population (Ryan, 2013; and Ariola, 2006). This was applied as follows in Equation below:

$$n = \frac{N}{1 + N(e^2)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

where, n= the sample size,

N = the population size

e =the level of precision

Demographic information about the owner of the farm was collected via gathering data about farming power source, age, farm size, education, years of experience, and the number of days worked off the farm.

Based the data gathered from each district the following unprocessed data were obtained:

- 17,546 households in Ada'a wereda Bishoftu area are found as farmers to consider tractors in this area 12 tractors are owned by a single company Joy Tech Farms.PLC and the other is from the farmer in total 13 tractors.
- 22,000 farmer households in Mi'esso wereda and 21 households are considered under users of the targeted tractors.
- 35,000 farmer households are found in Oda Buultum wereda 11 households owns fourwheel small capacity tractors.

  Using Mamane's formula mentioned above the total number of respondents were given as follows:

  $n = \frac{74546}{1+74546\times(0.05)\text{^}2} =$ 397 respondents were considered in our study

From these figures 45 were owners or operators of four-wheel small capacity tractors.

Respondents in each district= $\frac{\text{Total Number of respondents}}{\text{Total number of districts}} = \frac{397}{3} = 132 \text{ respondents} \ldots\ldots\ldots (3.2)$

131 respondents from the district of Ada'a Bishoftu area were gathered from kebeles of (Denkaka, Qorto and Tedecha), 132 respondents in mi'esso wereda includes (Mi'esso, Odabla and Gorbo) where as in Oda Bultum district 134 respondents were from (Burqa, Gosseso and Cinqo) among the lists 118, 121 and 123 respondents were non-users of four-wheel small capacity tractors from the respective districts of Ada'a, Mi'esso and Oda Bultum. whereas 13, 25 and 11 respondents were adopters of the targeted tractor types in Ada'a, Mi'esso and Oda Bultum districts. The proportional distribution of respondents is shown in the table 3 below

Table 3. Sample size distribution in targeted areas

Districts	No of Kebeles	No of respondents of non-users	No of respondents of SMHP tractor users	Total no of respondent
Odabultum	3	123	11	134
Mi'esso	3	121	21	132
Ada'a Bishoftu area	3	118	13	131
Total	9	352	45	397

3.5. Sampling Technique

Respondents were selected with the objective to get a broad understanding of the topic and diverse perspectives including stakeholders from farming, research, development cooperation and small- and large agricultural machinery businesses. The study was employed by two stage sampling procedure. The primary sampling units were obtained from the two districts of west Harerghe and one district from East shoa in Oromia regional state where four-wheel small capacity tractors are available in large number and the respondents were selected by purposive sampling technique based on the presence of targeted tractor. The samplings were done in two phases based the selection of targeted areas by purposive sampling methods. During our investigation 3 kebeles (Qorto, Denkaka and Tedecha) from Ada'a Bishoftu area were purposively selected because, there are 13 four-wheel small capacity tractors which are properly managed. 3 kebeles (Cinqo, Gossesso and Burqa) are also selected in Oda Bultum wereda where 11 tractors are available and 3 kebeles (Mi'esso, Odabla and Gorbo) from Mi'esso wereda where 21 four-wheel small capacity tractors are allocated. Since most of tractors are defected to do any operation further and detailed investigations were focused on operating tractors.

Furthermore, a focus group discussion that was facilitated by local agricultural experts were carried out in Mi'esso kebele and joy-tech farms compound. the farmers were able to report first hand about their experiences. However, it must be taken into consideration that their answers may have been more positive in order to encourage development cooperation efforts. Farmers considered us as part of solution in deducting credit to buy the tractor and to repair the failed to resolve biased answers the experts explained about our objective. The interviews were carried out with the help of semi-structured questionnaires with individual modifications to account for their individual knowledge.

3.6. Data Analysis

A category system was developed with deductive and inductive approaches. Codes were initially developed based on a pre-defined structure that derived from the research questions and working hypotheses. A comprehensive questionnaire was designed to glean information from the farmers through one-to-one interviews, questioner and focus group discussion. The data were analyzed using an analysis tool of a computer packages (MS-excel and SPSS). One-way ANOVA,

independent T-tests, multivariate and univariate analysis were used to analyze and compare the differences among variables, dependent factors' effectiveness of utilization, farmer's decision to use the targeted tractors and perception of farmers towards using small capacity tractors. In all analysis p value less than 0.05 were used as a statistical significance difference while in regression 95% confidence interval were statistically significance difference. Collected data were interpreted and analyzed in the form of a tables, bar graphs, and charts. These were done using research questions and finding of the study, numerically data were analyzed keeping descriptive method such as average and percentage values; and statistical methods as a parameter.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. House Hold Characteristics

4.1.1. Resource endowment and socio-demography of the study areas

Table 4. Resource endowment and socio demography of the study areas

Categories	factors	Deter factors	Number	Percent (%)	Pearson Correlation With interest to use tractors	Mean square	Sig.
Resource Endowment	oxen	For farming	160	40.3	-.049	.003	.938
		Mixed farming	194	48.9			
		For raring	43	10.8			
	land size	<2ha	107	30.3	-.010	.001	.943
		(2-4)ha	193	54.7			
		>4ha	52	14.7			
	Off farm income	I have	111	28	-.011	.042	.653
		I don't have	286	72			
	Credit access	No	92	23.2	-.043	.153	.356
		Yes	305	76.8			
	Farm asset	Poor	61	15.3	-.072	.911	.168
		Medium	195	49.1			
		Satisfied	141	35.5			
Socio-demography	Edu. Level	Illiterate	177	50.2	+.092	1.215	.004
		Basic	157	44.6			
		educated	18	5.2			
	Marital Status	Single	55	13.9	.011	.023	.673
		Married	342	86.1			
	Age	<36	84	23.8	+.029	.388	.437
		36-54	124	35.1			
		>54	141	39.9			
Bio physical properties	Land degradation	High	94	23.7	+.065	.990	.200
		Medium	155	39			
		Low	148	37.3			
	plot fertility/slope	Bad	6	1.5	-.103	4.210	.041
		Fair	234	58.9			
		Good	157	39.5			
Groups/social capital	Group participate	No	57	14.4	+.013	.001	.935
		Yes	340	85.6			
	GO/NGO support	No	57	14.4	+.013	.001	.935
		Yes	340	85.6			

As shown in the table 4 above about (48.9%) of the respondents have oxen for the purpose of both farming and raring, (40.9%) have for farming operation and the remaining 10.8% used the oxen for raring to earn money by selling to the market. An average farm asset for the targeted group is (49.1%) medium and (35.5%) satisfied in fulfilling their basic need and other requirements. According to our investigation the percentages are appreciable with parallel reasons such as availability of credit access (76.8%), accessibility of farm size (54.7%) having (2-4) ha and (30.3%) have less than 2 ha the remaining 15% have above 4 ha. The group participation (85.7%) of the study groups are best in understanding the importance of team work as a result of this the land degradation is low (37.3%) and (39%) is medium, plot fertility is better (58.9%) fair and (39.5%) is good. For all these reasons the access of support both by the governmental and private stake holders play a great role (85.6%). The table above further reveals that educational level of the respondent and the plot fertility significantly affects the interest of farmers in adopting the targeted tractors with a significant level of $p<0.05$. In continuation with the idea that the variables could either have a positive or a negative influence on the final adoption behavior, we suggest that each geographical location would possess varying composites of variable influence. Therefore, we have listed our assumption on the direction of the relationship between our dependent and independent variables. The number of oxen, the size of the farm, availabity of off-farm income, credit access, farm asset, plot fertility and marital status have a negative correlation with the interest of farmers in using the four-wheel small capacity tractors. Whereas educational level of respondents, age, land degradation, group participation and access to support have a positive correlation to the interest of the respondents in using the tractors.

4.1.2. Information access and farming practices of the respondents

Table 5. Information access and farming practices of the areas

Categories	Determinant factors	Variables	Number	Percentage (%)	Pearson Correlation with interest of respondents	Mean square	Anova Sig.
Information access	Access to extension	No	36	9.1	+.081	.003	.938
		Yes	361	90.9			
	general information	No	196	55.5	-.256	6.219	.000
		Yes	156	44.2			
	Farming experience	Bad	60	15.2	+.082	.000	.960
		Fair	165	41.6			
		Good	169	42.6			
	Awareness about tractors	No	195	49.1			
		Yes	202	50.9	-.142	1.494	.014
Farming practices of farmers	Using trend of technologies	No	248	62.5		2.668	.001
		Yes	149	37.5			
	Farm power source	Animal	342	88.7		.004	.615
		Machine	45	11.3			
	Interest to use the tractors	Interested	175	44.1	1		
		Not interested	222	55.9			
	Loss of interest (why?)	Negative perception	245	61.7			
		Un able to afford	152	38.3			

As indicated in the table 5 above the general information is not disseminated fairly (55.5%), only about (44.2%) can access information with relatively proper manner. Basic reasons that can be mentioned for improper general information's includes low level of technology utilization trend (62.5%) don't have technology using interest, negative perception (61.7%) have bad attitude towards using the targeted tractors that indirectly influences the interest of end users in selecting the targeted tractors.

The availability of extension service (90.9%) for farmers has played a great role in advancing the existing interest of respondents in using four-wheel small capacity tractors. Even though the availability of extension service is appreciable about (55.9%) of the respondents are not interested to adopt the targeted tractors. According to the table 5 above the interest of farmers in using the targeted tractors is

negatively correlated with the general information and awareness about the capability of the targeted tractors. The determinant factor is positively correlated with access to extension and farming experience of the respondents. Furthermore, awareness creation about the capability of four-wheel small capacity tractors, technology utilization practices and availability of general information have an influence with a significance level of ($p<0.05$).

As revealed in appendix C-7 bad perception and low understanding is created since the educational level of the respondents is not beyond basic skills of writing and reading of which about 50.1% are illiterate, 44.5% are basic and only 5.5% are better to understand different issues of using technological advancements. For the listed drawbacks many reasons can be shown among these land is fragmented, irrelevant information dissemination among end-users, awareness about tractors.

From the targeted respondents (44.1%) are interested to use the four-wheel small capacity tractors in contrary (88.7%) from the targeted group do not have small capacity four-wheel small capacity tractors. Because (61.7%) of the respondents are affected with a negative image created directly or indirectly by different actors of the mechanization and low understandings about the overall capacity of tractors in accomplishing the farming activities. the distribution of the targeted tractors is low and the available tractors are not effectively used. The second reason of obstacle to start using the focused tractors is, they considered that they can't afford the cost.

4.1.3. Factors influencing farmer's decision in using four-wheel small capacity tractors

Table 6. Factors influencing the interest of farmers to use the tractors

Source	Type III Sum of squares	Df	Mean square	F	Sig.
Education level	.723	2	.361	3.138	.045
Farm size	.310	2	.155	1.347	.261
Access to info	1.314	1	1.314	11.410	.001
Farming experience	.272	4	.068	.590	.670
Awareness about tractors	.448	1	.448	3.890	.049
Access to support	.096	1	.096	.831	.363
Credit access	.121	1	.121	1.055	.305
Perception of farmers	35.350	3	11.783	102.329	.000

From the reference of table 6 the study found that more farmers were interested to use small capacity tractors the remaining respondents don't have interest to adopt, their reasons include of fragmented farm land, low understanding of the productivity of tractors and in capability to afford the machineries. Generally, the following investigations have been generated by simple analysis done as shown in the table above and appendix 5:

- ✓ Education level affects an interest to use machines with a significant level of ($p<0.05$) from the participants (92.5%) use animal power to do their agricultural activities only (7.5%) have tractors the numerical figure shows the number of tractors available in the target area. (47.7%) are illiterate, (43.5%) are basic to education and (8.9%) are well educated who are engaged in farming sector by renting land, helping and sharing with their families.
- ✓ Knowledge of four-wheel small capacity tractors: From the total respondents of non-users of four-wheel small capacity tractors about 75.7% of the participants knows the targeted tractors. As shown in table 6 knowledge of the tractors affects the interest of farmers towards using tractors with a significant level of ($P<0.05$).
- ✓ Perception of farmers about the effectiveness of tractors: The perception of farmers in using small capacity four-wheel tractors is almost bad ranging in number 46.2% bad, 42.4% fair and only (11.8%) have good attitude towards using the discussed tractor series. As a

determinant factor of interest to use tractors the perception of farmers affects their interest in using the targeted tractors with the level of $p<0.05$ significance. For this access to information in different arenas has a contribution influencing the idea of farmers in using the tractors with $p<0.05$ level. From table 6 it is shown that the independent factors have effects on the interest of farmers in using the four-wheel small capacity tractors in the selected areas with statistically significant level. In addition to this the factors are statistically significant in their difference.

From the perspective of our study areas the following factors have been found as major factors influencing in using of four-wheel small capacity tractors:

a, Technical performance: farmers considered that the work rate and impact of technology on timeliness of operations are not tangible. Due to these farmers considered the targeted tractors as useless.

b, Financial returns: gross margins, break-even analysis, source of finance, individual or group ownership benefits are not affordable from using four-wheel small capacity tractors. Many reasons can be mentioned for the fact among them pre-distribution studies were not done, dealers don't take responsibility, natural and technical feasibility studies were not undertaken.

c, Social implications: total labor requirements, division of tasks between household members, and impact on quality of life were not amended. Because most the distributed tractors were failed to do in short period of time.

d, Machinery support services: ability of existing infrastructure to maintain and repair new technologies, access to spare parts, technical information, training and advisory services has been investigated as factors influencing in using four-wheel small capacity tractors. In general, as it is indicated from the table 6 education level, access to information, understanding the expectation (perception) of farmers and knowledge of the available four-wheel small capacity tractors are major factors that affects the interest and adoption of tractors in the targeted study area with a significance of ($P<0.05$) level.

4.1.4. Experience and perception of farmers towards using four-wheel small capacity tractors

Table 7. Determinant factors for adopting four-wheel small capacity tractors

	Sum of Squares	Df	Mean Square	F	Sig.
Education	11.556	1	11.556	36.235	.000
Marital status	.161	1	.161	1.275	.260
Farm size	3.179	1	3.179	7.557	.006
Farm asset	.341	1	.341	.712	.399
Off farm income	.459	1	.459	2.244	.135
Access to info	10.918	1	10.918	50.315	.000
Farming experience	18.877	1	18.877	2.224	.137
Awareness of respon	.182	1	.182	.724	.395
Access to support	.342	1	.342	1.574	.211
Group participation	.611	1	.611	5.054	.025
Farm power source	.001	1	.001	.051	.821
Interest to use	2.789	1	2.789	11.660	.001
Credit access	.589	1	.589	3.310	.070
Live stock	2.763	1	2.763	6.072	.014
Perception of farmers	4.574	1	4.574	6.054	.014
Labor availability	.002	1	.002	.003	.958
Access to extension	.719	1	.719	9.133	.003

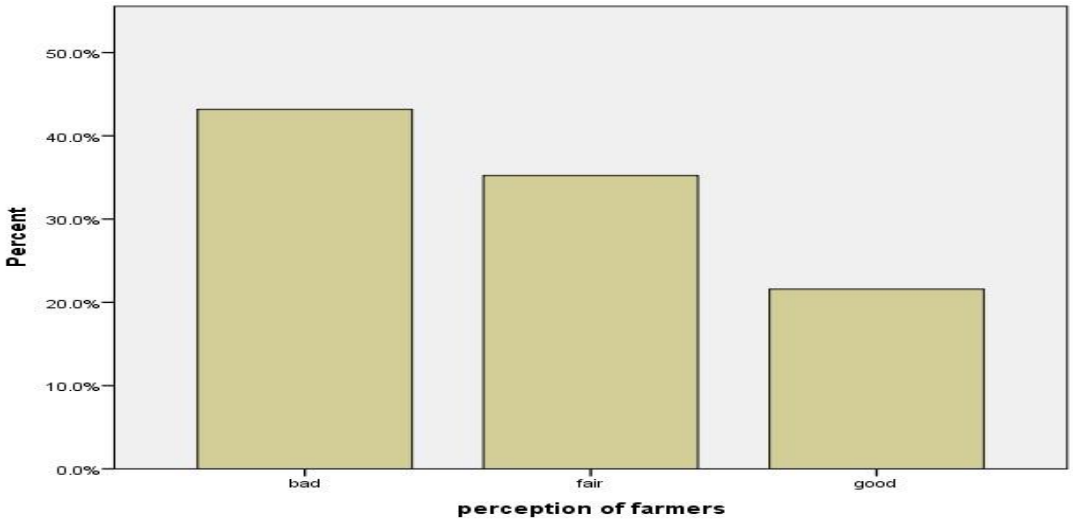


Figure 2. Perception of farmers towards using the tractors

Social, economic, cultural, awareness creation and political and institutional factor are major influencing impacts which can upgrade or reduce the utilization of four-wheel small capacity tractors in specific and many agricultural machineries in general. As it is revealed from table 7 the major influencing factors for the targeted areas are: education level, farm size, access to information, group participation, interest to use the technology options, availability of credit access, livestock availability, optimistic perception of farmers towards the need of using four-wheel small capacity tractors and accessibility of extension experts all the listed determinant factors affects the overall condition of farmers in using four-wheel small capacity tractors significantly ($P<0.05$).

It is known that farmers who are less educated and less experienced with modern technologies, are often hesitant to serve as, "guinea-pig" and hence working with more advanced farmers in this regard might be a proper way to introduce the technology to the area. Based on the investigation positive perceptions towards using the targeted tractors are reduced concerning the number of distributed four-wheel small capacity tractors. for this many reasons can be raised among these tractors failed to do the farming activity within a month after distribution, lack of trainings, un studied distribution, farmer's expectation about the performing capacity of tractors, lack of after-sales service, selection problems of machines for the specified soil type and educational level of end-users.

The study in figure 2 showed that (41.4%) of the respondents have a good experience in using different agricultural technologies. Regardless of their previous experience, (53%) of the

interviewed farmers were positive about trying the tractor using service (if available in the area). This implies that 47% of farmers are not willing to use four-wheel small capacity tractors service.

Based on the response from the farmers the conditions to be improved in changing the perception of farmers towards using four-wheel small capacity tractors:

(1) Farmers had a positive expectations regarding the quality of tractor plowing: low level of education, lack of trainings, inappropriate competitions of dealers to distribute un studied tractors, irresponsibility of the governmental stake holders and private sectors are major influencing factors affecting the perception of farmers in using the targeted tractors. To resolve the challenge mechanization policies and strategies shall be revised.

(2) The economic performance of targeted small capacity tractors should be more attractive than the traditional system. It should be less labor intensive and properly selected in doing the required task with timeliness.

(3) Social-cultural factors. According to survey results, the majority of the farmers can access credit and technology supply as a result of this group participation approaches are important to share technology development information's.

(4) Political and institutional factors. Close collaboration with the government at all levels is a crucial condition for successful introduction of the targeted tractors. Hence, stakeholder meetings and involvement of district and Kebele extension centers are key condition.

(5) Awareness creation. The decision to use credit to pay for the tractor buying would be a very new idea to farmers as they have the money yet.

4.2. Availability and distribution of four-wheel small capacity tractors

According to our physical observation four-wheel small capacity tractors are mini tractors which are easy in operation, available in simple design, can be served within small turning cycle and cost effective to be chosen based on pre distribution studies. Table 8 below shows the frequency and the percentage of each variables for each determinant factors. The table is established from the structured questionnaires that were addressed for end-users, dealers, private and governmental stakeholders.

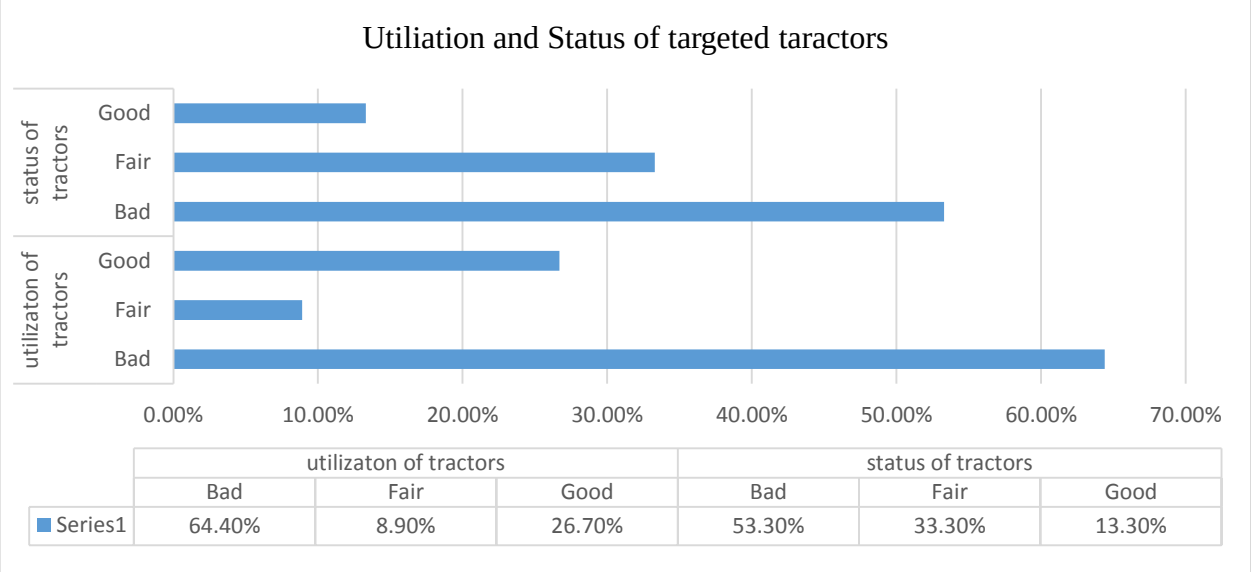
Table 8. Availabity and distribution of the targeted tractors

Factors	Variables	N	Percentage	Factors	Variables	N	Percent
Districts	Ada'a	13	28.9%	After sales service	Bad	31	68.9%
	Mi'esso	21	46.7%		Fair	1	2.2%
	Odabultum	11	24.4%		Good	13	28.9%
Durability of machines	Bad	24	53.3%	Tractors are effective	Don't Agree	22	48.9%
	Fair	15	33.3%		Partially Agree	10	22.2%
	Good	6	13.3%		Completely Agree	13	28.9%
Performance test	No	44	97.8%	Utilization of tractors	Bad	29	64.4%
	Yes	1	2.2%		Fair	4	8.9%
					Good	12	26.7%
Ownership	By Credit	31	68.9%	Operating skill	Bad	24	53.3%
	Buying	14	31.1%		Fair	12	26.7%
Machinery status	Bad	24	53.3%				
	Fair	15	33.3%				
	Good	6	13.3%				
Trainings given	Bad	39	86.7%				
	Fair	6	13.3%				

The distribution of four-wheel small capacity tractors in the focus areas covers M'isso (46.7%), Ada'a Ada'a wereda (28.9%) and the remaining (24.4%) belongs to Oda Bultum wereda. All the tractors in Mi'esso and Oda Bultum wereda are owned by credit, whereas in ada'a wereda. The tractors are distributed via direct purchasing from the company. As indicated in table 8 most of the assessed tractors are found in Mi'esso wereda (46.7), Ada'a wereda (28.9%) and Oda Bultum districts (24.4%) respectively. In general, the status of machineries about (53.3%) is bad because (97.7%) of the investigated tractors didn't considered for performance testing and trainings were not given to operators and owners that indicates (86.7%) are bad in delivering trainings, operating skill of drivers is not good (53.3%) bad skill of operation.

Among the respondents about (48.9%) of the participants do not agree on the effectiveness and capability of the targeted tractors because effective utilization of the tractors is not good that indicates about (64.7%) of the respondents do not use four-wheel small capacity tractor effectively.

4.3. Status and utilization of four-wheel small capacity tractors



	utilizaton of tractors			status of tractors		
	Bad	Fair	Good	Bad	Fair	Good
Series1	64.40%	8.90%	26.70%	53.30%	33.30%	13.30%

Figure 3. Utilization and status of four-wheel small capacity tractors

According to the physical investigation in the study areas the most common frequently failures for the targeted tractors are steering and in some cases engine stoppage. However, we have seen that tractors are durable if proper management is applied. In Ada'a Bishoftu area most of the management skills are good. Since the companies are large scale farm enterprises, directly importing spare parts. Trainings are offered with a progressive attachment of tractors and aftersales services are manageable. In our investigation of the causes of defect for the tractors we found that

there are no spare parts, most operators are illiterate and the targeted tractors were exposed for steering system defects (33.3%) and for engine stoppage 17.8%. Defects (exploitations) of the maximum number of tractors are not known (48.9%). Because it requires a technician and expert in the areas. The following table shows the effect of different factors influencing the utilization.

Table 9. Univariate analysis of utilizing the targeted tractors

Variables	Sum squares	Df	Mean Square	F	Sig.
Education	28.357	2	14.178	86.454	.000
Farm size	11.417	2	5.709	29.144	.000
Farm asset	7.133	2	3.567	89.880	.000
Off farm income	3.785	2	1.892	10.654	.000
Access to extension	.228	2	.114	6.378	.004
Farming experience	6.380	2	3.190	9.436	.000
Use of tech	8.249	2	4.125	11.155	.000
Access to support	1.460	2	.730	3.939	.027
Credit access	7.133	2	3.567	89.880	.000
Machinery status	11.090	2	5.545	19.889	.000
Durability of machine	11.090	2	5.545	19.889	.000
After sales service availability	34.050	2	17.025	260.018	.000
Most frequent failing part	24.954	2	12.477	47.827	.000
Can the tractors be effective	24.243	2	12.122	56.839	.000

As shown in table 8, indicating distribution of tractors (53%) from the investigated tractors are in bad condition and failed to do their operations. As a result of this farmers lost interest to use and were incapable to return their financial billing of buying tractors, because (68.6%) of tractors are owned by credit. Information's gathered from dealers, governmental stake holders and Adama tractor factory indicated that more than (80%) of the farmers did not pay the cost of the tractors. Whereas respondents (farmers), wants any concerned body to take back tractors which are fallen in the gardens of farmers. Based on the table 9 above indicating the main effects of determinant factors in utilizing four-wheel small capacity tractors are significantly affected by access to support

of different agricultural inputs and facilities with a significance level of $p<0.05$. Education level of respondents, farm size, credit availability, farming experience, the trend of using agricultural technologies, access to extension services, after sales service offer, the venerability of machines for most frequent failures effectiveness of tractors, durability and status of the targeted tractors affects the utilization of four-wheel small capacity tractors with $p<0.05$ significance levels. The means of the listed variables are statistically different from effective utilization of the four-wheel small capacity tractors by the significant level of ($p<0.05$)

4.4. The durability of four-wheel small capacity tractors

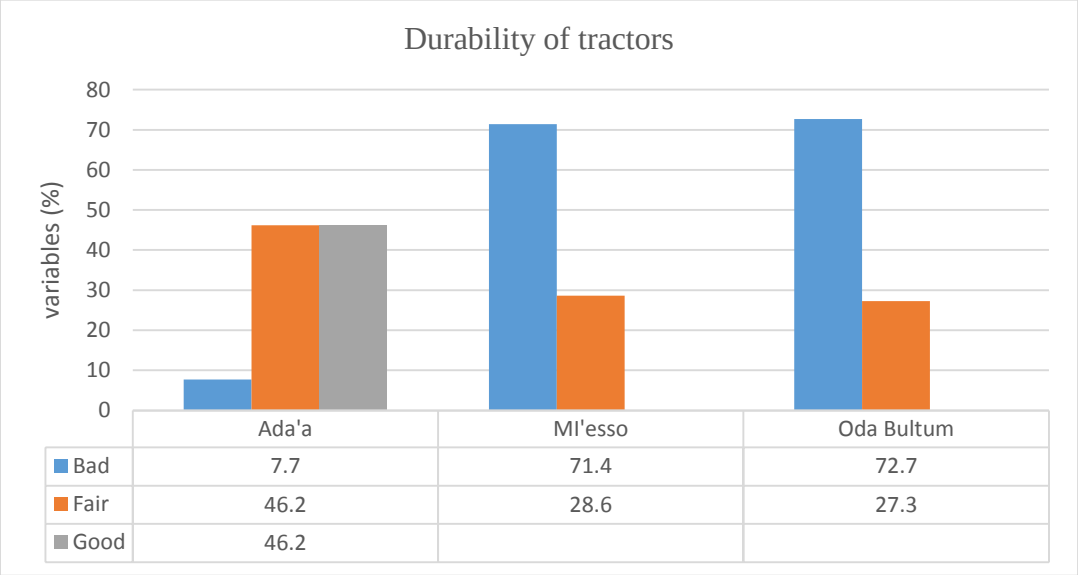


Figure 4. Durability of four-wheel small capacity tractors

During our investigations we found many tractors that have been serving for more than six years with simple defects which could have been treated with simple maintenance. Availability of after sales service, good operator's skill, technological advancement to use agricultural machineries and other factors played a role to prolong duration of targeted tractors. Ada'a district is one example for the case accessing after-sales service and other facilities. As indicated in figure 4 above the durability of tractors are more related with the closer availability of facilities for machinery management service. (61.5%) of the operators in Ada'a district are good in operating the machineries and (38.5%) have gotten trainings in operation and maintenance services. All the tractors access after sales service, because joy tech PLC can bring spare parts with direct order from the manufacturer of tractors as a result of this tractors are serving with full capacity ranging

a service life of seven years. The service life of tractors in Mi'esso and Oda Bultum districts are low because there are no after sales service, trainings, spare parts and awareness of farmers about tractors is bad since the purchased tractors were not served properly due to in appropriate machinery management.

4.5. Machinery management of four-wheel small capacity tractors

4.5.1. Comparison of service viabilities based on district

Table 10. Comparing viability of four-wheel small capacity tractors

Factors	Variables	Number	mean of square	Mean Difference	Sig.	T
education	plain	13	1.0000	.65625	.000	
	hilly	32	.3438			4.870
farming exp	plain	13	2.000	.65625	.001	7.693
	hilly	32	1.844			1.517
access to support	plain	13	1.000	.1563	.000	2.396
	hilly	32	.594			2.730
credit access access to support	plain	13	.077	.3750	.000	4.313
	plain	13	1.000			2.915
	hilly	32	.594	.4063	.001	4.605
machinery status	plain	13	.923			-19.156
	hilly	32	.281	-.9231	.000	-12.00
Durability of machine	plain	13	1.385			4.707
	hilly	32	.281	.6418	.030	5.755
after sales service	plain	13	1.000			6.474
	hilly	32	.031	1.1034	.198	5.582
failing part	plain	13	.231			19.624
	hilly	32	1.625	.9688	.102	31.000
project failures	plain	13	.462			-7.481
	hilly	32	.188	-1.3942	.008	-8.583

effectiveness	plain	13	1.000			1.919
	hilly	32	.313	.2740	.000	1.712
utilization	plain	13	1.000			5.228
	hilly	32	.094	.6875	.015	8.258
ownership	plain	13	1.000			10.958
	hilly	32	.031	.9063	.198	17.311
performance test	plain	13	.077			19.624
	hilly	32	.000	.9688	.001	31.000
operating skill	plain	13	1.000			1.596
	hilly	32	.250	.0769	.000	1.000
farm power source	plain	13	1.000			6.105
	hilly	32	.219	.7500	.000	9.644
trainings given	plain	13	.385			6.661
	hilly	32	.031	.7813	.000	10.522
farm size	plain	13	2.000			3.503
	hilly	32	1.750	.3534	.000	2.456

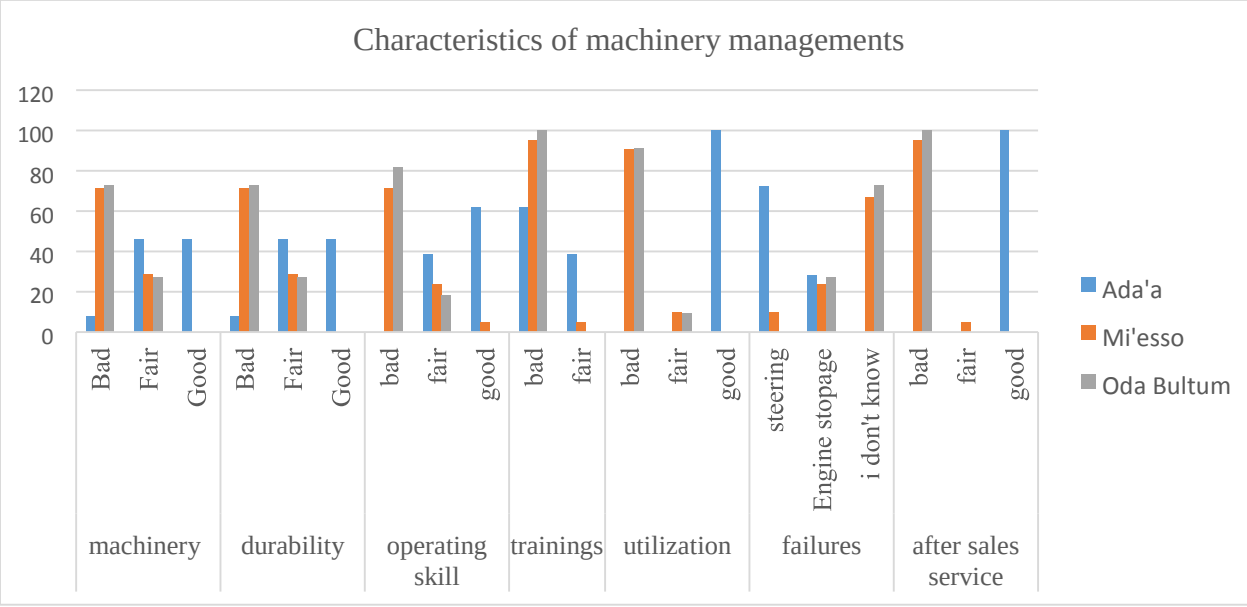


Figure 5. Characteristics of machinery management in the study areas

As mentioned in section three (material and method part) subsection of ‘’description of study area’’ west Harerghe as a zone is not uniform in its topographic land scape the area is up and down and hilly. Due to this we have denoted both districts (Mi’esso and Oda Bultum) as low land and hilly topography and Ada’a district as plain, even there might be error in leveling accordingly.

Services got varied attention concerning the topography, soil type, proximity to management access of agricultural machineries socio-cultural situation and demographic condition of the society**.** As revealed from the table 10 above the overall machinery status is good in Ada’a district than the two districts with statistical significance level of ($p<0.05$), because the educational level and perception of farmers in the area is better. durability of machineries and utilization of available equipment’s are better treated in Ada’a wereda than the two districts with significance level of ($p<0.05$). Ability of operators to operate machineries with efficiency (61.5%) are good to operate and (38.5%) are fair to operate with significance of ($p<0.05$) than the remaining two districts. Issuance of trainings having a fair access (38.5%) can be taken as reason, while there is no training given to other districts and is statistically significant with ($p<0.05$). in Ada’a district viability of after sales service with a good access of spare parts has enhanced the status, durability and utilization of small capacity tractors than Mi’esso and Oda Bultum districts located 300km and 337km away from Adiss Ababa respectively. Educational level in the area is also one factor affecting the level of utilization, status and durability of small capacity tractors than the two districts with significantly different from zero and $p<0.05$ the status of available four wheel-small capacity tractors making better in Ada’a district than Mi’esso and Oda Bultum districts.

4.5.2. Comparing the perception of four-wheel small capacity tractor users on tractor's effectiveness

Table 11. Independent T test to compare perception of farmers in using the tractors

Factors	Variables	Number	Mean of square	Mean difference	Sig.	T
trainings given	don't agree	22	.000			
	agree	23	.261	.261	.000	-2.787
Districts	don't agree	22	1.41			
	agree	23	.52	.89	.098	5.060
durability	don't agree	22	.273			
	agree	23	.913	.64	.030	35.406
ownership	don't agree	22	.318			
	agree	23	.609	.291	.000	-5.850
use of tech	don't agree	22	.591			
	agree	23	.870	.279	.000	.037
after sales service	don't agree	22	.000			
	agree	23	.609	.609	.000	-5.718
utilization	don't agree	22	.091			
	agree	23	.609	.518	.000	
credit access	don't agree	22	1.000			
	agree	23	.478	.522	.000	4.899

As it is revealed in the table 11 independent t-test analysis respondents who had an access to training are positive agreed towards the effectiveness of four-wheel small capacity tractors than who didn't take trainings with a significance value ($p<0.05$). tractor users who are well in managing machineries having a fair utilization trend agrees in the effectiveness of the targeted tractors with significantly ($p<0.05$). respondents who have durable tractors by using their method of prolonging efforts have a good perception in using four-wheel small capacity tractors than owners with defected tractors. As a result of this the targeted tractors are effective with significance level of ($p<0.05$) than respondents with bad perception towards using four-wheel small capacity

tractors. According to the findings respondents who have access to credit believed that the available targeted tractors can be effective than those who didn't access credit. This shows that the coefficient is statistical significantly different from zero and if preferable conditions are fulfilled the level of significance for their agreement is ($p<0.05$). Groups who are closer to technology practices and have technology access agreed on the effectiveness of four-wheel small capacity tractors with ($p<0.05$) than those who live far from the main city. From the targeted tractor users those who bought the tractor had a fair and positive attitude towards the effectiveness of fourwheel small capacity tractors than those who owned by credit with a significance level of ($p<0.05$). In general respondents who have a good access to credit, efficient in machinery utilization, owners who have a durable and prolonging (safe) tractors, who have a good access of after-sales service, advanced users of technology, who owned targeted tractors by their purchasing price and who have got training in maintenance and operation of four-wheel small capacity tractors are significantly optimist on the effectiveness of the targeted tractors than their contrary.

4.5.3. Comparing the field work rate of the tractors and implements

The actual and calculated rates of work for the different field operations were performed at the farmers' farm as shown in the table 12 below The results of each field operation for individual machinery with each implement is indicated.

Table 12. Work rate analysis with Anova

Operation	Sum of Squares	Df	Mean Square	F	Sig.
Ploughing	8.901	2	4.451	2.312	.247
Disking	.997	3	.332	4.763	.023

The statistical analyses of the actual and calculated rates of work with respect to their implements is shown in table 12, revealing the operating work rate for disc harrow is significantly different at the significance level of $p<0.05$. whereas the statistical significance is not different in the case of disc plow implement

Table 13. Actual and calculated work rate variation

Tractor cap & Implement	Travel Speed (km/hr)	width of implement (m)	actual Work rate (ha/hr)	Calculated Work rate (ha/hr)	Variation (%)
TY-254-DP	1.6875	0.87	0.11	0.147	25
TY-254-DH	6.8	1.29	0.685	0.88	22
YTO-404-DP	3.52	1.07	0.28	0.374	25
YTO-404-DH	10.78	1.57	0.36	0.71	49

Table 13 shows the actual and calculated rates of work for the different implements. The result affirms that the work rate done by disc harrow implement is greater than the disc plow, because width of implement and speed of operation were higher. The highest work rate variation (49%) was observed by the implement of disc harrow pulling YTO-404 model tractor at the operating speed of 10.78 km/hr. the least result of variation was (22%) at the operating speed of 6.8km/hr by the TY-254 with disc harrow implement. From both results we can make a conclusion that the work rate variation didn't depend on the type of implement. Maximum work rate was observed when the farming operation was accomplished by YTO-404 because the capacity of the tractor is much better than TY-254 and the service life of the tractor is most recent. In general, the working rate variation of tractors' is better achieved with the implement of disc harrow than disc plow.

Among the reasons which can be mentioned includes soil condition during when the farming operation was take over, depth of work, width of implement and speed of operation. Thus, concerning our case the rate of work for any operation mainly affected by speed, draft and implement operating width.

4.5.4. Power requirements of tractors

The power requirement was evaluated to see the variation between actual and calculated power of the targeted tractors with selected attachments.

Table 14. Actual and calculated power requirement of sample targeted tractors

Tractor with Implement	Travel Speed (km/hr)	Draft (KN/m^2)	width of imp lement(m)	Actual PTO power required(KW)	PTO Calculated power KW	20% PTO power (KW)	Calculated power required(KW)	Variation (%)
TY-254DP	1.6875	3.7	0.87	19	3.2	0.64	3.84	80
TY-254DH	6.8	2.17	1.29	19	11.34	2.268	13.6	28.4
YTO-404DP	3.52	5.02	1.07	30	11.02	2.2	13.2	56
YTO-404DH	10.78	4.15	1.57	30	40.97	8.19	49.16	-64

Table 14 shows the actual and calculated power required for the different field operations. They were varied widely due to variations in field operation speed, draft requirement and operating implement width. It was observed that the actual power requirement was based on the preference of the distributor and end users in some extent. the calculated power requirement was based on mathematical calculations suggested by Edwards *et al*., (2001). From table 14 it is shown that the highest value of power was occurred at 10.78km/hr for the YTO-404 model tractor with disc harrow implement. This was because the operating speed was higher, width of implement was greater and the soil condition was preferably moist relative to the other tractors with their respective implements.

The actual and calculated power variations for the different field operations were also given in Table 14 in most of our cases the actual power are greater than the calculated power requirements. Maximum calculated power was recorded for YTO-404 model tractor with disc plow. For this width of implement and operating speed are major reasons. Generally, for the total power required, the farmers used more than the power required in some field operations by about 25%. It was also observed that the actual power exceeded the calculated power in ploughing by 3.4%. These results

revealed that the more power used, may cause over-head costs which adversely affect the profit purposes of the field operations. While less than what required power may cause overload or operation failure. To overcome the economic performance loss maximizing operation precision, proper matching of implements and power source should be considered.

4.6. Spare Part Status

It is observed that most of the farmers specially in Mi'esso and Oda Bultum districts spend their time on equipment problems. Since the volume of inventory required is dependent on a large degree of usage, the fewer parts we use, the timeliness will be in doubt. The challenge was to determine what a correct inventory should be and how to manage it. From the study as shown in figure below, the situation of the spare parts during the study is poor.

In most of the farmers' farming activities, there was no effective and efficient way of spare parts availability, planning and control system. As it is indicated in the figure below about (68.9%) of after-sales service is bad. According to our investigation the status of spare part unavailability is the major reason for the poor utilization and distribution of targeted tractors in the selected areas. Joy tech farms PLC in Ada'a district has a good access to spare parts (28.9%) availability that imports accessories from the manufacturer of the tractors with a direct order. This should be shared as a good trend in which dealers and distributors shall make connection to share experience.

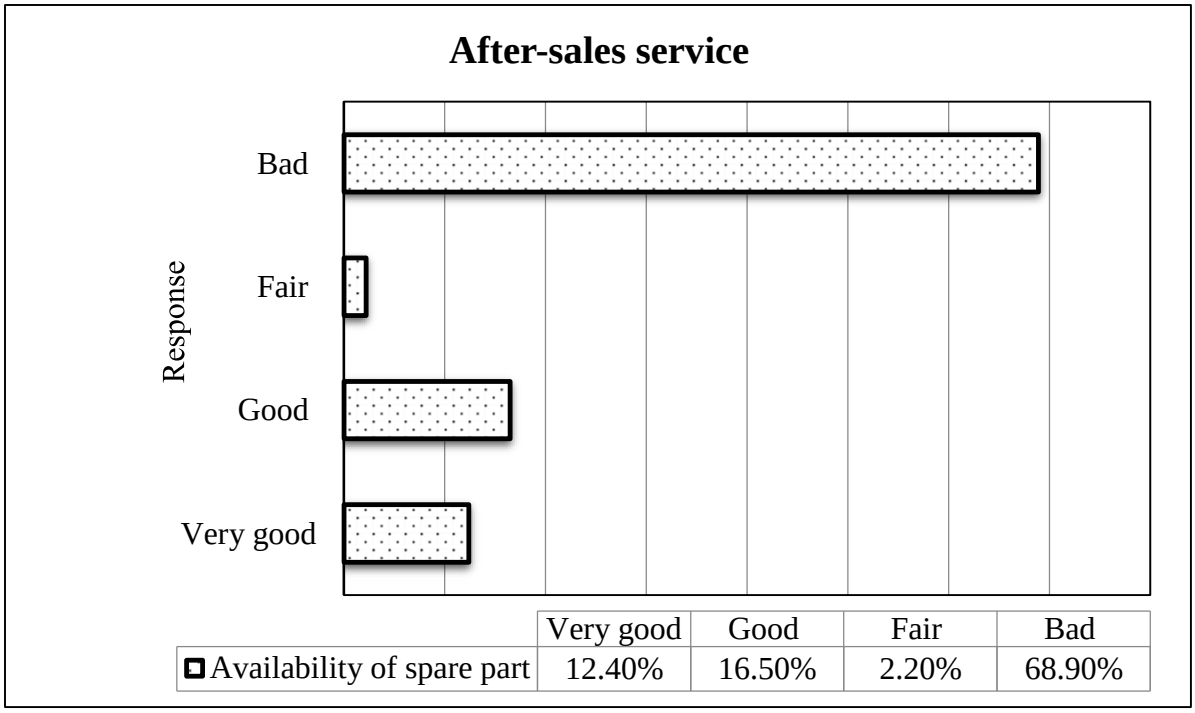


Figure 6. Status of after sales service in the study areas

The availability of the important spare parts during the season have a great effect on the performance of the machinery. However, usually machinery or equipment stoppage during was common, due to mainly un-availability of a given spare part, lack of skilled man power to maintain simple defects.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The focus area of the study analysis was on assessment of constraints, impacts and opportunities such as education, farm asset, access to information, demographic condition, access to support and credit availability which are important determinants to evaluate the current status of technology utilization to increase productivity in many arenas. About 71.4% farmers in the study areas have a good practice making off farm income through raring, trading, renting house and services. These opportunities are common because most of the respondents are near to the administrative town of the district.

This study has reviewed past studies on the factors influencing the current status of agricultural technology. Perception of farmers towards a new technology is a key precondition for adoption to occur. factors that have been shown to determine adoption of agricultural technology include human specific factors, economic factors, technological and institutional factors. From the review, the determinant of agricultural technology adoption does not always have the same effect on adoption rather the effect varies depending on the type of technology being introduced. Understanding the factors that influence or hinder adoption of agricultural technology is essential in planning and executing technology related programmers for meeting the challenges of food production in developing countries. Therefore, to enhance technology by farmers, it's important for policy makers and developers of new technology to understand farmers need as well as their ability to adopt technology in order to come up with technology that will suit them

To conserve limited resources, great attention must be given to the effective utilization and exploitation of farm machineries available in the hands of end-users. From this study it could be concluded that, availability of four-wheel small horsepower tractors has a great role in increasing productivity of farmers if there are necessary spares parts, proper management systems, technical knowledge sharing among farmers, opportunities to develop the trend of performance evaluation of tractors before using in different soil types and specific task, awareness created among stakeholders in business sector and government officials. As a result, they can pass their order to lower class experts to expand technology utilization by the end-users, proper information's are

disseminated about the effectiveness of small horsepower tractors if they are selected according to technical principles. In most cases of evaluating the performance of four-wheel small capacity tractors, we have found that as the velocity increases fuel consumption, wheel slip, drawbar power, and draft force also increases. This is acceptable when compared with previous works. In relation to the above facts, studying the social factors and the determinants influencing the utilization of four-wheel small capacity tractors and analyzing the efficiency in accomplishing the required task is tried to be addressed.

The proportion of the sample assigned to each area was based on the density of small capacity four-wheel tractors in the Oromia region. Since there is more information access and farming experience is fair and good (80%) in the areas. The finding is good for agricultural development in the targeted areas, considering that agricultural activities around the area involve a greater tendency to adopt due to the existence of awareness about the small capacity four-wheel tractors (50.1%). Concerning this, only about 43.3% of the farmers are interested to adopt the targeted tractors. Even though the accessibility of information and awareness about the tractors are fair in the area but the technology utilization interest is low (37.7%). This could be due to the policies, strategies, platforms, stakeholders, and dealers don't address major challenges in mechanization development.

According to our investigations the distribution and utilization of four-wheel small capacity tractors are affected due to the following reasons: site changing of end users, lack of sufficient, training, operators don't have special license, dealers don't give due attention to the interest of farmer, credit access is not supplied sufficiently, crop production is not full package.

Among the respondents, availability of credit access (76.5%), accessibility of large labor (93.8%), and accessibility of the agricultural extension systems (92.1%) have mentioned the presence of a good opportunity in the development of the sector if the ministry of agriculture and other actors in the sector can play a role for a common benefit.

From the results of the study, the following conclusions could be depicted:

- Major factors influencing utilization of mini tractors including human-specific factors, economic factors, technological and institutional factors were differentiated.

- Since the distribution of four-wheel small capacity tractors was not on the basis of prolonged pre-studies a huge economic crisis has occurred and this has resulted in the loss of interest to use the tractors by changing the perception of farmers towards tractors.
- From our findings, we have seen that the perception of most farmers and even the distributors about the tractors is bad. However, our investigation result indicates that tractors are efficient if proper selection of soil type, type of operation, availability of aftersales service, and other farm machinery management strategies are considered.
- Low understanding of farmers about the tractors, site changing of end-users, lack of sufficient training, unavailability of special driving license for operators, Irresponsibility of dealers and distributors in giving attention to the effective utilization of tractors, insufficiency of credit access to the interested end-users and seasonality of the product resulting in exposure of tractors to repeated defects are major challenges which result in the phasing out of the distributed tractors.
- Even though four-wheel small capacity tractors ownership is likely to decrease shortly, the social status associated with the ownership of the tractor will most likely remain a crucial factor to take into account while introducing a technology that does not need the tractors.
- The condition for evaluation of the current status of tractor services was the quality of tractor plowing, the economic performance of a mechanization service (like affordable cost and reduced time and less labor use) should be a more attractive and close collaboration with the government at all levels is a crucial condition for the successful introduction of the targeted tractor services.

5.2. Recommendations

The following recommendations are forwarded based on the study as the best solution for the problem identified-

❖ Care should be taken during machinery selection to match the power unit size with the amount of work to be done and implemented based on reasonable estimation. It is important to study cost, soil type, type of tractor, and implement to use so that well studied selection of machinery has a good impact in utilization and exploitation of farm machinery.

❖ The determinant factors should be differentiated before distributing agricultural technologies to save the cost to be invested in the sector, which requires studying the performance of machinery with their attachment and studying long lasting of the proposed project in the farmer community.

❖ The agricultural sector in general and the agricultural machinery in specific shall be managed and led by the targeted professionals of the sector.

❖ Machinery operators should be qualified and trained to perform the job properly to increase machine efficiency and reduce fuel and machinery costs.

❖ The government or the private sector should set up agricultural machinery centers that can support in maintenance and repair of tractors to small-scale farmers at subsidized rates.

❖ According to our physical investigation we found that YTO series tractors are well in performing agricultural activities, therefore we would like to recommend that this tractor should be further studied and distributed for the end-users for whom they are farming a similar soil profile having similar soil properties.

❖ There are a lot of tractors that are wasted in the hands of the farmers, these tractors shall be serviced and simple treatments shall be done including delivering spare parts.

❖ The systems of farm machinery repair and maintenance, as well as training programs for mechanics and operators required to be evaluated.

❖ Re-arrangement and compartment of the related field machinery administrations, further investigation on-farm power and machinery systems selection and replacement are required.

❖ The ranges in implement draft, fuel consumption, and other mentioned parameters indicated that substantial energy savings could be readily obtained by selecting energyefficient tillage implements and by proper matching of the tractor size and operating parameters to the tillage implements.

❖ Obtained data could be used by district farmers for selecting the best combination of tillage implements, size of tractor and tractor implement match.

❖ From our assessment, it was found that their service life is appreciable and simple performance test confirms tractors are efficient under different circumstances and parameters, therefore it is recommended that governmental and private sectors shall play a role in using tractors to improve agricultural productivity.

❖ Finally, pre-distribution studies and performance evaluation tests shall be taken as a mandatory before delivering to the farmers.

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ANNEXES

Annex 1-A. Tools used in field and laboratory work

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Annex 2-A. Targeted tractors in the field work

Annex 3-B. Structured questionnaires disseminated for non-users

Structured questionnaires to gather information on the status of machines and perception of farmers in using tractors

1, Are you male or female? A. Male B. Female

2, On which age category are you included? A. Less than 36 B. 36 to 55

C. Greater than 55

3, What is your education level? A. Illiterate B. Basic C. Educated

4, Are you married or single? A. Single B. Married

5, How much is your farm size? A. Less than 2ha B. (2 to 4) ha C. Greater than 4 ha

6, What is your wealth index? A. Poor B. Medium C. Rich

7, How many livestock do you have? A. Less than 3 B. 3 to 5 C. Greater than 5

8, Do you have off farm income? A. No B. Yes

9, Are you accessing to extension advice? A. No B. Yes

10, Are you experienced in farming? A. No B. Yes

12, Are you aware of four-wheel small capacity tractors? A. No B. Yes

13, What is your level in agricultural technology utilization? A. Bad B. Fair C. Good

14, Is there land degradation? A. No B. Yes

15, How is your land fertility? A. Infertile B. Fertile

16, How far is your home from market or road A. Far B. Near

17, Is there governmental or non-governmental financial support A. No B. Yes

18, Is there social capital in working together A. No B. yes

19, Is there financial credit access? A. No B. yes

20, How is an availability of labor in the working area? A. No B. Yes

21, What is your farm power source? A. Animal B. Machine

22, Are you interested in using four-wheel small capacity tractors? A. No B. Yes

23, If your answer is No why? (A). low understanding (B). small farm land (C). high price

Annex 4-B. Questionnaires for users

1, For what purpose are you using four-wheel small capacity tractors (A). Self-use (B). Rental service

2, How is your machinery management? (A). Bad (B). Fair (C). Good

3, Level in operating your tractor? (A). Bad (B). Fair (C). Good

4, What are needed implements in your farming? (A). Trolley (B). Tillage (C).Spraying (D). Mixed

5, How is after sales service in your locality? (A) Bad (B). Fair (C). Good

6, Did your machine test ever before? (A). No (B). Yes

7, How is your machinery status right at the moment? (A).Bad (B) Fair (C). Good

8, Is there technicians around? (A). No (B). Yes

9, How do you explain the durability of your tractors? (A). Bad (B). Fair (C). Good

Annex 5-B. Questionnaires for distributors, dealers and agricultural biro

1. What is your main focus area in agricultural mechanization?
2. What are the challenges you faced in the distribution of the targeted tractors?
3. How many four-wheel small capacity tractors do you distributed by your own organization and in which area?
4. Are you satisfied in achieving your goal by addressing small capacity tractors to end-users?
5. Which type of implements are more needed?
6. How did you distribute the tractors, criteria's?
7. Do you know how many tractors are currently in the hands of end users?
8. Have you given training for farmers on four-wheel small capacity tractor?
9. Have you gathered feedback from tractor users? If yes, what you got?

10. Is there any study conducted in your center in relation to the targeted tractors? If your answer is yes would you, please indicate the major findings of the study?
11. which brand and model is more wanted?
12. do you give training on four-wheel small capacity tractors to farmers?
13. Do you have workshop to your customer nearby the farm area?
14. How do you distribute four-wheel small capacity tractors for the farmers? 15. Have you gathered defects most frequently happened from four-wheel small capacity tractor users? If yes, please tell us.
21. which tractor capacities and brands are most durable from the targeted tractors?

Annex 6-C. Laboratory work sample taking parameters

The main objectives of work in the laboratory are to study and confirm the specifications and essential components comparing them to those given by the manufacturer and to undertake such studies that may assist in modification and improvement of the implement design. It includes:

a) Adjustment of working width _____cm

b) Depth _____cm

c) Type, of coulter available _____cm

d) Vertical adjustment of the coulter _____cm

e) Material of plough share _____cm

f) Weight of soil working parts before test _____cm

g) Towing arrangements _____cm

Tractors used for the test should be compatible with the implement under test and be driven by experienced operators.

Annex 7-C1. Velocity and performance parameters

tractor&imple	Velocity (km/hr)	Draft (KN)	Draw bar power (kw)	OEE	Wheel slip (%)	Fuel consumption (L)
TY254DP	1	1.92	0.53	0.1	18.61	12.28
TY254DP	1.5	2.58	1.08	0.13	21.34	10.7
TY254DP	2	3.01	1.42	0.15	24.2	6.9
TY254DH	1.5	1.49	0.62	0.09	9.43	13.27
TY254DH	2.5	1.57	1.09	0.15	10.76	11.75
TY254DH	3.3	1.88	1.72	0.19	11.59	8.65
TY254DH	4	2.12	2.36	0.23	12.07	9.17
YTO404DP	1.5	4.06	1.69	0.17	9.76	19.82
YTO404DP	2.5	4.21	2.92	0.29	10.3	16.06
YTO404DP	3.3	4.45	4.08	0.33	12.7	12.65
YTO404DP	4	4.68	5.2	0.35	12.42	11.96
YTO404DPH	1.5	2.21	0.92	0.17	7.94	11.81
YTO404DH	2.5	2.64	1.83	0.32	8.29	10.66
YTO404DH	3.3	3.14	2.87	0.36	9.96	7.42
YTO404DH	4	3.2	3.56	0.39	11.45	7.01

Annex 8-C2. Generation of work rate from field efficiency

trac&impl	Sam Number	*(*Productive time), hr	(Non-productive time) hr	*Area (ha)*	Total time	EFC (ha/ hr)	TFC (ha/hr)	Field efficiency (%)
TY-254DP	1	0.5	0.21	0.11	0.72	0.15	0.23	65
	2	0.55	0.18	0.11	0.73	0.151	0.225	67
	3	0.58	0.15	0.11	0.73	0.151	0.225	67
TY-254DH	1	0.127	0.04	0.11	0.167	0.659	0.856	77
	2	0.136	0.043	0.11	0.179	0.615	0.83	74
	3	0.133	0.046	0.11	0.179	0.615	0.83	74
YTO-404DP	1	0.35	0.14	0.11	0.49	0.22	0.31	72
	2	0.41	0.11	0.11	0.52	0.21	0.3	70
	3	0.38	0.12	0.11	0.5	0.22	0.31	72
YTO - 404DH	1	0.11	0.03	0.11	0.14	0.786	0.94	84
	2	0.1	0.036	0.11	0.136	0.81	0.942	86
	3	0.11	0.033	0.11	0.143	0.77	0.93	83

Annex 9-D. Frequency and percentage of the house hold characteristics

Categories	Determinant factors	Variables	Frequency Number	Percentage (%)	Categories	factors	Deter factors	Number	Percentage (%)
Information access	Access to extension	No	36	9.1	Resource Endowment	oxen	For farming	160	40.3
		Yes	361	90.9			Mixed farming	194	48.9
	general information	No	196	55.5			For raring	43	10.8
		Yes	156	44.2		land size	<2ha	107	30.3
	Farming experience	Bad	60	15.2			(2-4)ha	193	54.7
		Fair	165	41.6			>4ha	52	14.7
		Good	169	42.6		Off farm income	I have	111	28
	Awareness about tractors	No	195	49.1			I don't have	286	72
		Yes	202	50.9		Credit access	No	92	23.2
Farming practices of farmers	Using trend of technologies	No	248	62.5			Yes	305	76.8
		Yes	149	37.5		Farm asset	Poor	61	15.3
	Farm power source	Animal	342	88.7			Medium	195	49.1
		Machine	45	11.3			Satisfied	141	35.5
	Interest to use the tractors	Interested	175	44.1		Land size	<2ha	107	30.3
		Not interested	222	55.9			(2-4)ha	193	54.7
	Loss of interest (why?)	Negative perception	245	61.7			>4ha	84	23.8
		Un able to afford	152	38.3					
Bio physical properties	Land degradation	Low	94	23.7					
		Medium	155	39	Socio-demography	Edu. Level	Illiterate	177	50.2
		High	148	37.3			Basic	157	44.6
	plot fertility/slope	Bad	6	1.5			educated	18	5.2
		Fair	234	58.9		Marital Status	Single	55	13.9
		Good	157	39.5			Married	342	86.1
Groups/social capital	Group participate	No	57	14.4		Age	<36	84	23.8
		Yes	340	85.6			36-54	124	35.1
	GO/NGO support	No	129	32.5			>54	141	39.9
		Yes	268	67.5					

annex 10-E Correlation between determinant factors

		land degrade	plot fertility	distance to market	access to support	group participation	credit access	labor availability	farm power source
land degrade	Pearson Correlation	1	.054	.305**	-.220**	.287**	.252**	.016	.051
	Sig. (2-tailed)		.285	.000	.000	.000	.000	.744	.311
	N	397	397	397	397	397	397	397	397
plot fertility	Pearson Correlation	.054	1	.077	-.018	.051	.011	.010	.013
	Sig. (2-tailed)	.285		.128	.727	.308	.819	.844	.803
	N	397	397	397	397	397	397	397	397
distance to market	Pearson Correlation	.305**	.077	1	.018	.090	-.007	-.198**	.063
	Sig. (2-tailed)	.000	.128		.722	.073	.888	.000	.214
	N	397	397	397	397	397	397	397	397
acces to support	Pearson Correlation	-.220**	-.018	.018	1	-.141**	-.069	.021	-.031
	Sig. (2-tailed)	.000	.727	.722		.005	.172	.677	.540
	N	397	397	397	397	397	397	397	397
group participation	Pearson Correlation	.287**	.051	.090	-.141**	1	.116*	.013	.055
	Sig. (2-tailed)	.000	.308	.073	.005		.021	.801	.276
	N	397	397	397	397	397	397	397	397
credit acces	Pearson Correlation	.252**	.011	-.007	-.069	.116*	1	.104*	.074
	Sig. (2-tailed)	.000	.819	.888	.172	.021		.039	.143
	N	397	397	397	397	397	397	397	397
labor availblity	Pearson Correlation	.016	.010	-.198**	.021	.013	.104*	1	-.090

	Sig. (2-tailed)	.744	.844	.000	.677	.801	.039		.075
	N	397	397	397	397	397	397	397	397
farm power source	Pearson Correlation	.051	.013	.063	-.031	.055	.074	-.090	1
	Sig. (2-tailed)	.311	.803	.214	.540	.276	.143	.075	
	N	397	397	397	397	397	397	397	397
interest to use	Pearson Correlation	.065	-.103*	-.097	-.150**	.013	-.043	.073	.042
	Sig. (2-tailed)	.198	.041	.054	.003	.802	.396	.148	.406
	N	397	397	397	397	397	397	397	397
reason not to use	Pearson Correlation	-.112	-.313**	-.037	-.121	.257**	-.181*	-.415**	.137
	Sig. (2-tailed)	.130	.000	.615	.104	.000	.014	.000	.065
	N	183	183	183	183	183	183	183	183
acces to info	Pearson Correlation	-.088	.078	.145**	.121*	-.120*	.006	-.028	-.121*
	Sig. (2-tailed)	.080	.122	.004	.016	.017	.909	.578	.016
	N	397	397	397	397	397	397	397	397

		distance to market	acces to support	group participation	land degrade	marital status	education	farm size	age
distance to market	Pearson Correlation	1	.018	.090	.305**	.022	-.014	-.061	-.024
	Sig. (2-tailed)		.722	.073	.000	.660	.779	.225	.627
	N	397	397	397	397	397	397	397	397
acces to support	Pearson Correlation	.018	1	-.141**	-.220**	.037	.105*	-.048	.026
	Sig. (2-tailed)	.722		.005	.000	.460	.037	.345	.609
	N	397	397	397	397	397	397	397	397
group participation	Pearson Correlation	.090	-.141**	1	.287**	.002	.101*	-.021	-.068
	Sig. (2-tailed)	.073	.005		.000	.966	.043	.679	.174
	N	397	397	397	397	397	397	397	397

land degrade	Pearson Correlation	.305**	-.220**	.287**	1	-.014	-.149**	-.093	-.130**
	Sig. (2-tailed)	.000	.000	.000		.775	.003	.065	.009
	N	397	397	397	397	397	397	397	397
marital status	Pearson Correlation	.022	.037	.002	-.014	1	.053	.249**	.052
	Sig. (2-tailed)	.660	.460	.966	.775		.296	.000	.305
	N	397	397	397	397	397	397	397	397
education	Pearson Correlation	-.014	.105*	.101*	-.149**	.053	1	.177**	-.097
	Sig. (2-tailed)	.779	.037	.043	.003	.296		.000	.054
	N	397	397	397	397	397	397	397	397
farm size	Pearson Correlation	-.061	-.048	-.021	-.093	.249**	.177**	1	-.018
	Sig. (2-tailed)	.225	.345	.679	.065	.000	.000		.722
	N	397	397	397	397	397	397	397	397
age	Pearson Correlation	-.024	.026	-.068	-.130**	.052	-.097	-.018	1
	Sig. (2-tailed)	.627	.609	.174	.009	.305	.054	.722	
	N	397	397	397	397	397	397	397	397
farm asset	Pearson Correlation	-.055	-.159**	-.037	.106*	.278**	-.060	.531**	-.089
	Sig. (2-tailed)	.277	.001	.464	.035	.000	.235	.000	.078
	N	397	397	397	397	397	397	397	397
live stock	Pearson Correlation	.205**	.034	.146**	.407**	.042	-.008	-.020	-.026
	Sig. (2-tailed)	.000	.497	.004	.000	.398	.874	.698	.607
	N	397	397	397	397	397	397	397	397
off farm income	Pearson Correlation	.071	.137**	-.129*	-.081	-.010	.239**	-.006	-.060
	Sig. (2-tailed)	.158	.006	.010	.107	.841	.000	.910	.230
	N	397	397	397	397	397	397	397	397
acces to exte	Pearson Correlation	.112*	-.036	-.099*	.087	-.097	-.134**	-.294**	.026
	Sig. (2-tailed)	.026	.478	.050	.082	.054	.008	.000	.602
	N	397	397	397	397	397	397	397	397
farming exp	Pearson Correlation	-.170**	.034	.020	.002	.050	.061	.162**	-.035
	Sig. (2-tailed)	.001	.505	.684	.969	.322	.225	.001	.485
	N	397	397	397	397	397	397	397	397