EVALUATION OF EFFECTIVENESS AND ADOPTION OF WALKING TRACTOR IN CASE OF AMHARA REGION:

By

ETSEGENET FIKRU MELAKU

DEPARTMENT OF MECHANICAL SYSTEM AND VEHICLE ENGINEERING
SCHOOL OF MECHANICAL, CHEMICAL AND MATERIALS ENGINEERING

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

Office of Graduate Studies

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

Adama, Ethiopia

October, 2021

EVALUATION OF EFFECTIVENESS AND ADOPTION OF WALKING TRACTOR IN CASE OF AMHARA REGION

By:

Etsegenet Fikru

Advisor:

Simie Tolla (Ph.D.)

Department of Mechanical Systems and Vehicle Engineering

School Of Mechanical, Chemical and Materials Engineering

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

Office of Graduate Studies

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

Adama, Ethiopia

October, 2021

ADVISOR APPROVAL SHEETS

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled “Evaluation of effectiveness and adoption of walking tractor in case of Amhara region” prepared under My guidance by Etsegenet Fikru Melaku submitted in partial fulfillment of the requirement for the degree of Masters of Science in Agricultural Machinery Engineering. Therefore, I recommend the submission of revised version of the Thesis to the Department following applicable procedure.

_____	_____	_____
Name of advisor	Signature	Date

DECLARATION

I, hereby declare that this Master thesis entitled “Evaluation of effectiveness and Adoption of walking tractor in case of Amhara region” 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.

_____	_____	_____
Name of student	Signature	Date

This MSc Thesis has been submitted for examination with my approval as a thesis advisor.

_____	_____	_____
Name of advisor	Signature	Date

APPROVAL OF BOARD OF EXAMINERS

I, the advisor of this thesis entitled “Evaluation of effectiveness and adoption of walking tractor in case of Amhara region” and developed by Etsegenet Fikru Melaku, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated in to the final version of the thesis.

_____	_____	_____
Name of advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Etsegenet Fikru Melaku have read and evaluated the thesis entitled “Evaluation of effectiveness and adoption of walking tractor in case of Amhara region” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfilment of the degree of Masters of Science in Agriculture Machinery Engineering.

_____	_____	_____
Chairperson	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date

Final approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Post Graduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

_____	_____	_____
Head of Department	Signature	Date
_____	_____	_____
School Dean	Signature	Date
_____	_____	_____
Post Graduate Studies Dean	Signature	Date

ACKNOWLEDGMENT

First of all I would like to thank the almighty God, who gave me the commitment and tolerance to pass various obstacles and come up to the accomplishment of this thesis. Next, I am very grateful for my research advisor; Dr. Simie Tola Who has encouraged, directed, and given me academic advisory throughout the research work with good heart and patient.

I am grateful to all the targeted districts agricultural extension workers for their positive co-operation and support in the data collection for this thesis work. Special thanks shall also go to Mr.Teshome Alemayehu, (agricultural extension worker in Machakel district), Mr.Merkebu Mekonnen, (agricultural expert in Basoliben district), Salina Hassen, (marketing and sales engineer in Amio engineering) and Dessye Belay (associate researcher in Fogera national rice research and training center) in giving me valuable information at the time of data collection. Also, my deepest gratitude was extending to Adama Science and Technology University for its support by providing facilities through research.

Finally, I would like to express my deepest gratitude to my parents; for their idea and financial support throughout the duration of study, and to my friends who contributed to this thesis in one way or another.

Table of Contents

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

ACRONYMS

AAMI	Adama Agricultural Machinery Industry
AGP	Agricultural Growth Development
ANOVA	Analysis of Variance
AOR	Adjusted Odd Ratio
CIMMYT	International Maize and Wheat Improvement Center
COR	Crude Odd Ratio
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (In English; German Corporation for International Cooperation)
LSD	Least Significance Difference
MoA	Ministry of Agriculture
RF	Reference
SG	Sasakawa Global
SNNP	South Nation Nationalities and Peoples of Ethiopia
SPSS	Statistical Package for social science
2WT	Two Wheel tractor

ABSTRACT

Walking tractors are viable alternative for transition from small holder farming to commercial farming and engine power source for Sub-Saharan Africa like Ethiopia. However, most of walking tractors were not effectively utilized and adoption of walking tractor was not proficient. Therefore, this study aimed to investigate ineffectiveness of the walking tractor in adoption to the targeted areas with its associated factors. Cross-sectional study design was conducted and a structured questionnaires were prepared and a total of 420 respondents were equally selected from 12 kebeles in the four targeted districts. Binary logistic regression, one way ANOVA, t-test and fishers exact test were used to evaluate factors associated with adoption and effectiveness of walking tractors. In this study finding, factors such as training, lack of operating skill, absence of spare part and maintenance service could affect both adoption and effectiveness of walking tractor. Education status, land size, cost of waking tractor and rental service were factors that affect adoption of walking tractor. Whereas topography, soil condition and difficulty on operation of walking tractors were factors that affect effectiveness of walking tractor. Participants who had primary and above education levels were 42 and more times as well as participants who had adult education were 2 and more times more likely to adopt walking tractor than illiterates. The participants who had land size of greater than 2 hectare were 6 and more times more likely to adopt Walking tractor than those who had less than 1 hectare of land. Respondents who gained training about walking tractor were 17and more times more likely to adopt walking tractor than that of respondents who didn't gain training. Participants who used walking tractor through rental service were 3 and more times more likely to adopt walking tractor than those who didn't use walking tractor by renting. The significant difference in effectiveness of walking tractor between red soil type with sand and black soil with p- value 0.005 and 0.001 respectively; the result indicates walking tractor was effective on red soil than sand and black soil type. While the significant difference between plain area with hilly and dipping topography were p=0.007 and p=0.002 respectively indicated that topography was one factor that affect effectiveness of walking tractor. There was a significant difference between plowing time with farmers who gained training and who did not (p=0.028).walking tractor is an ideal technology that facilitate modern farming system so that further studies will conduct to improve the performance based on soil type and topography as well adoption of the walking tractor in the region and in the country level at large.

Keywords: walking tractor, adoption, effectiveness, training, maintenance and spare part.

1 INTRODUCTION

1.1 Background of the Study

In Ethiopia, Agriculture is characterized by smallholdings, due to high population density with nearly two-thirds of the population residing in rural areas (EIAR, 2017). Their life and livelihood are based on agriculture. Farmers have been using animal traction Ard plough, known as Maresha, for thousands of years. An Ard plough or Maresha is an assemblage of pointed steel tipped tine attached to drought of a pair of animals at an adjustable shallow angle with narrow side wings. It totally weights 17 to 25 kilogram with travel speed of 0.35 to 0.5 m/s (Gebresenbet and Kaumbutho, 1997; Goe, 1997). As Temesgen *et al*., (2008) stated that using animal drawn tillage equipment, sufficient soil preparations are not achievable. Due to the profile of the Maresha, incomplete turnover of furrows is achieved. As a result of the poor pulverizing nature of the equipment, the farmers are obliged to make multiple pass. In addition to these, shallow depth of plows hinders the water infiltration and root growth. This significantly limits the plant growth and annual yields (Temesgen *et al*., 2008).

As Getachew S. (2020) study indicates that at the time of tillage, the farmer keeps on guiding the oxen and controlling the depth of penetration. Both the farmers and the animals need to be well experienced in order to make good furrows. These facts indicate how much plowing is a laborious activity. Hence, a farmer alone may not have enough time to prepare the soil well before the seeding season passes, the farmer demands the help of more man power and more animal power. The above mentioned problems can be solved using agricultural machineries, which can give better soil preparation and field coverage (Getachew S., 2020).

Agricultural mechanization has a significant contribution to agricultural development and its purposes are increasing land and labor efficiency by reducing the difficulty in farming operation, bringing more lands under cultivation, save energy and resources. The development and utilization of improved agricultural practices and technologies in rural areas should get emphasis to bring continued growth and transformation in agriculture. Through the Agricultural mechanization, economic growth is promoted through higher yield per hectare and expansion of the cultivated area, either by incorporation of new land or by the possibility of carrying out more than one plantation per year, in the same area unit (Negrete and Jaime, C., 2014).

The Ethiopian government has adopted agricultural-led industrialization as central plank of its development program, with a focus on growth of productivity in the sector. Many studies reported that benefits of more production and productivity from increased farm power/energy (Faleye*etal*., 2012).Apart from improved crop yield, the increased usage of farm power for cultivation creates further demand for related agricultural machinery for harvesting, storage and to add value to primary products and so generates employment opportunities and income potential along the value chain (Sims, *etal*., 2016). 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.

Ethiopia has a long history of involvement with the introduction of tractors (especially four-wheel tractors). To nurture agricultural mechanization, state farms both irrigated and rain fed has played a very big role, especially during the second period of the previous socialist regime, large mechanized state farms were established (about 200,000 hectares) out of which about 47,000 hectares were irrigated (Jonathan et al., 2011). In the 70s to 90s period another mechanization approach tried in the period was government operated tractor hire schemes. These were later abandoned; partly due to heavy financial burden on the government as a result of subsidizing the service (CIMMYT, 2014). However, farm mechanization has progressed little in Ethiopian smallholder agriculture due to cost and fragmented land.

since, 2011, the use of various types of tractors has shown a definite increased trend (for example, the number of imported 4WT increased from 547 in 2005 to 2940 in 2013), and the projected demand would expect to increase from 4375 (in 2014) to 14532 (in 2017). The reason is that due to the increased attention of the government for commercial farmers, availability of financial support for investment, increased foreign direct investment). However, the demand for 2 -wheel tractor (2WT) is scattered existence in Ethiopia and only few farmers are using it (Tadess 2014).

Successful increase per ha field cultivated has been positively affected by the increased use of power-tillers in countries like Malaysia, Indonesia and Pakistan. From the foregoing, it is clear that power tillers or fondly called 2WT are viable alternative for transition from small holder farming to commercial farming (Haque and Bell 2015).2WT are viable engine power source for Sub-Saharan Africa where big tractors are either costly to maintain and/or to purchase (Haque *et al., 2011*).For small holder farmers to larger operations walking tractors can make a

lot of sense. Walking tractors are much more maneuverable than traditional four wheel tractors and their company profile allows them to work in areas where traditional four wheel tractors cannot. Walking tractors are also less cost than larger tractors but can still use in a variety of applications.

From the questioner that was filled by Amhara Region Agricultural Bureau, I have understand that mechanization status in the region progressed little. The main crops grown in Amhara region were Maize, Sorghum, Teff, Wheat, Field pea, Bean, Haricot, and Rice. In the past two years the farmers have used different agricultural machineries and implements through rental service from Amhara region agricultural Bureau. For this rental service more than 700 tractors, 82 combine harvesters, 22 maize thresher were giving mechanization service for farmers and shows a good attribute. The future plan for mechanization in the region is to adopt different agricultural machineries for farmers by purchasing and rental service.

The response of east and west Gojam agricultural directors, there were different investors, unions and organizations that gives agricultural machinery rental service for farmers, such as, Guzamen union in Debre Markos, Damot union and ministry of public enterprise Ethiopian agricultural business corporation in Bure district. Ethiopian agricultural business corporation states that they give different mechanization service for farmers through rental service in Bure district such as, harrowing, ploughing, seedling, harvesting and transporting. But the practice of mechanization activities was progressed little, in east Gojam from 650,000 hectare of land only 3000 ha of land plowing and harvested with tractor and combine harvester. The reasons behind this improper use of farm machinery includes; there was only one Mechanization professional, Farmers can't handle the machines properly due to a lack of practical knowledge and absence of maintenance service and it was a high impact for developing mechanization.

Based on the response of associate researchers in Fogera national rice research and training center, Ethiopian institute of agricultural research Fogera national rice research and training center in Woreta gives different mechanization service including ploughing harvesting and threshing through rental service for farmers, the main focus area of research center was machinery design, test and performance evaluation, serve for test of machineries for private and organization and adoption of improved implements, machineries and tools. They also have a program to introduce agricultural mechanization to small scale farmers through hand tools, animal drawn implements, Walking tractor drawn planter seeders, threshers and storage

technologies. In addition, they gives training for local manufacturers, technology importers and walking tractor users. In each year many farmers have an access of training in rice mechanization technologies in both pre harvest and post-harvest technologies. In the area the farmers have always high positive attitude towards mechanization and also a good interest on usage of walking tractor but they complained that the service about how they can get the machines.

The Ethiopian Ministry of Agriculture (MoA), Agricultural Mechanization Directorate, one of the country wise action performed to expand and enlargement of the usage of mechanization technologies is grouping young peoples, to rent the mechanization technologies to farmers. Agriculture Plan Program has purchased 100 walking tractors with four attachment implements for each walking tractor and distribute them to different districts to those grouped and trained young peoples. Accordingly, those young peoples are ready to give a rental facility and, in some districts', they have started farming service. Two wheel tractors and attached implements such as moldboard plough, disc plough and thresher would be distributed throughout the country in different ways such as directly supplied by MoA, directly supplied by international maize and wheat improvement center (CIMMYT**),** supplied by a rental hiring basis and purchased directly by farmers.

The number of walking tractors distributed by MoA in different districts of Oromia region such as Adami Tulu, Dugda, Arsi Negele, Welmera, Gudeya Bila and Tiyo were 4, 4, 4, 12, 6 and 6 respectively. In addition to this, the number of walking tractors distributed by CIMMYT in different districts such as Gudeya Billa, Gumbichu, Sinan and Tiyo were 13, 2, 2 and 6 respectively. Most of walking tractors in Oromia region were functional and give different farming activities for farmers. In Amhara region different district's such as Basobilen, Machakel. Semen Achefer, Guzamen, Awabel, Libokemkem and Basona. In Tigray region different district's such as Taytay Koraro, Ofla, Ambalage and Raya Azebo and in SNNP such as Lemo district and Hawassa zuriya. MoA mechanization directorate states that from those selected areas the potentially practiced areas are Tiyo in Arsi zone, Gimbicho, Machakel, Basona, Adwa and Ambalage.

1.2 Statement of the Problem

Ministry of Agriculture (MoA) has been implementing several activities targeting on improving agricultural productivity and production of small holder farmers. In the Second Growth and Transformation Plan, the government has emphasized improving farmer's way of farming by introducing new agricultural mechanization technologies and improving access to the mechanization technology service provision.

Since agriculture is one of the leading sectors in the country, the Federal Democratic Republic of Ethiopian (FDRE) through MoA supply walking tractors and attached implements for rising the agricultural sector and to change the traditional farming system to modern mechanized farming. In addition, CIMMYT and Sasakawa Global (SG**)** also supply walking tractors to support the government strategy in modernization of traditional farming system. The above mentioned governmental and non-governmental organizations have distributed walking tractors in the research areas such as Machakel, Basoliben, Guzamen, Awabel, Bure and Libo kemkem districts.

However, most of the walking tractors were not effectively utilized by the farmers. Hence, the FDRE through MoA and different organizations such as CIMMYT and SG allocated budget in the purchasing, transportation and distributing the walking tractors to the selected farming areas and some farmers purchased walking tractors directly but there was a constraint on this mechanization development practices. The users lose benefits from walking tractor and this ineffectiveness of walking tractor disturb mechanization development on small scale farming areas. The need of high initial investment, the lack of good road facility and the soil type and topography of the farm fields has remained bottlenecks. In addition to these, the fragmented and limited land holdings of the farmers are the other major problem standing against mechanization. This ineffective practice of walking tractors are also impact on adoption of walking tractors. Therefore, these is important to identify different factors which impeding effectiveness and adoption of walking tractor.

1.3 Objectives

1.3.1 General objective

The general objective of this research is to investigate effectiveness of the walking tractors in adoption to the areas Machakel, Baso Liben, Guzamen, Awabel, Libo kemkem and Bure Districts, Amhara Region.

1.3.2 Specific objectives

- To evaluate the current status and different practice of the walking tractors in the targeted districts;
- To evaluate and analyze the effectiveness of walking tractor in the targeted districts;
- To assess the factors hindering the adoption of walking tractor in the targeted districts;

1.4 Significance of the Research

Now a days, the Ethiopian government through MoA, together with CIMMYT, SG, GIZ and AGP distributes walking tractors in different parts of the country for developing mechanization. In fact, this research work investigated the effectiveness and adoption of walking tractor to improve farmer's productivity and give direction for adoption and effectiveness of walking tractor.

Generally, this research work is important:

- ✓ To enable the ministry of agriculture and other organizations that engage in mechanization, the findings of this study will be used as a guide for the effective use and adoption of walking tractors.
- ✓ To provide designers and importers have access to information regarding the problems in adopting a walking tractor.
- ✓ To provide researchers with access to the findings of this study so that they can utilize them as a guide.

1.5 Hypothesis

Factors that affect both adoption and effectiveness of walking tractor in the study area could be absence of training, lack of operating skill, absence of spare part and maintenance service. Land size, Education status of farmers and cost of waking tractor affect adoption while soil type and topography affects effectiveness of walking tractor.

1.6 Scope of the Research

The scope of this research was limited to evaluate the current trend on adoption of walking tractors and its effectiveness for small holder farmers in Machakel, Basoliben, Guzamen, Awabel, Bure, and Libo kemkem districts in East Gojam, West Gojam and South Gondar zones. The evaluation has been considered different parameters on factors for effectiveness and adoption of walking tractors through structured questionnaires, Interviews, field observation and focus group discussion. The boundary of problems investigated was determined effectiveness and adoption of walking tractors.

2 LITERATURE REVIEW

2.1 Farm Machinery

Agricultural mechanization deals with design, utilization and management of technical systems and processes of engineering for production, storage, treatment, and processing of agricultural goods. Agricultural mechanization aims to increasing land and labor use, working to increase the cultivated area, saving resources (seed, fertilizer, water), and improving energy products and quality protecting the environment; through proper use of inputs, saving sustainability of agricultural production, creating attractive jobs for men and women, to prevent rural exodus, improving farm management and multi farm use, and increasing farm income (Ali, 2005).

Farm machinery is an important element and fundamental for agricultural development and crop production in modern agricultural of many countries. The main objectives of the machinery are to reduce the difficulties of farm operations and to maximize production. Farm machinery is any equipment that farmers use to till, plant, cultivate, and harvest, including tractors, ploughs, discs, planters and combines (Omer,2013).The fact that mechanized farming minimizes loss or even transform it into profit through timely farm operations (Singh, 2014)

Farm power sources are categorized into human, animal, mechanical and a combination of them (FAO, 2006). Since ancient times animal power has been the predominant power available for tillage, threshing and rural transport to the Ethiopian farmers. Shortage and in efficient use of farm power limits the total area under cultivation and is responsible for low crop yield due to untimely-performed operations such as planting, weeding and harvesting, (Sims and Kienzle,2006).

Ethiopian agriculture is mainly rain fed with two rainy seasons: June-September (Meher season) and February-May (Belg season). The country's total arable land is 74 Million hectares (Guush, 2014). At present, only about 25 percent of its arable land is cultivated, and agriculture is dominated by subsistence rain fed farming, using fewer inputs and characterized by low productivity (Melaku, 2011).

Farm machinery plays an important role in agricultural production. It contributes a major capital input cost in most agricultural business. Farm machinery offers several potential

improvements for farming system such as increased land and labor productivity, reduction of risk, increase of food quality and save of time (Mohammed, 2015)

Ethiopia's farmers are also diverse; agriculture is dominated by smallholder farming. There are approximately 14.7 million households, of which, approximately 60% of which operate on less than 1 hectare of land while only approximately 1% of farmers operate on land greater than 4 hectares. They can be categorized: 1) Marginal farmers -farm size of less than 0.5 hectares and represent approximately 36% of the rural households. 2) Small farmers farm size between 0.5 and 1 hectare. 3) Semi-medium farmers- farm size between 1 and 2 hectares 4) Medium farmers- farm size between 2 and 10 hectares and 5) Large farmers- farm size that is larger than 10 hectares (Melesse, 2017).

Recently, ATA and MoA are developing Agricultural Mechanization Strategy based on experience of different countries. Until 2015, 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, only 22% is exclusively owned by the smallholder farmers. In other words, percentage of farmers owning plowing machines out of the total smallholder farmers is 1.21% (ATA annual 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%) (ATA strategy, 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.

The government has developed a mechanization strategy to increase the farm power per hectare to 1kW by 2025. However, the policy of imports only generously gives duty free imports of machineries to licensed investors; whereas the majority producers (the smallholders) need to pay the duty. These makes farm machineries unaffordable by the smallholders (Agricultural mechanization forum of Ethiopia, 2018)

2.2 Walking Tractor

Farmers plow their lands with hand-tools and bullocks at sloppy fragmented lands in most of the hilly areas. A four wheel tractor can work safely on slopes up to 8-10 percent, where plowing with bullocks is quite difficult. But walking tractor can work safely up to 13 percent

slopes on small area (Esdaile, 2012). Moreover, cultivation with two-wheel tractor is done ten times faster than manual hoeing and 2.5 times faster than animal-driven plow (Maamun, 1984).

The Power Tiller is a multipurpose tractor designed suitable for use in paddy fields, dry fields, vegetable gardens and hilly land with a little inclination. It can be used for plowing, rotor-tilling and in harrowing in paddy fields as well as harvesting, drilling, ditching and transportation. These power tillers can be called "single-axle tractor, walk-behind tractor, and hand tractor .It can also be extensively used as a stationary power source for small scale drainage and irrigation, spraying, grain threshing, cotton ginning, flour milling and feeder cutting. The concept of using power tiller drawn wheeled multipurpose tool carrier was introduced newly as a development of the animal drawn wheeled tool carrier. Though, the initial cost of equipment is slightly high, it offers several advantages like timeliness in farm operation, quality and precision of work, increased work rate, efficient utilization of machine power, reduction in human drudgery and allow for year round use due to its multipurpose utility. The popularity of these models among farmers is limited. The multipurpose tool carrier can be used for different operations like plowing, harrowing, tillage etc. by attachment with suitable implements. The efficient machine management requires accurate performance data on the capability of individual machine in order to meet the projected work and to form balanced mechanization system by matching the performance of separate items of equipment. (Sakai, 2009).Safety of using walking tractors is considered low in the area of crossing bunds and road accident in line with reports (Shridar *etal*, 2009). It can perform diversified operations by using a range of modified implements. In the neighboring countries, like Bangladesh, many farmers use seed drill, strip tiller (effective for minimum and zero tillage), rotary tillage seed drill, the versatile multi-crop planter with two-wheel tractor(2WT) (Haque *etal*., 2011).

Two-wheel tractors are sometimes called by other names such as: single axle tractor, hand-tractor, walking tractor, walk behind tractor, and the two-wheel tractor with different attachments (implements) can accomplish many kinds of farm work like tillage, planting, harvesting and transportation. When a tillage implement is attached to a two-wheel tractor, it is called power- tiller. There are many types of two- wheel tractors such as: mini tiller type (1.5 – 2.2 kW), traction type (2.9- 4.4 kW), Dual type (3.7 – 5.2kW), Drive type (5.2 – 10.3 kW), Thai type (5.9 -8.8 kW). (Y.S Ademiluyi *etal*.2008)The walking tractors are commonly known as power tillers that has been the part of farming system for many small farmers in developing

countries due to small farm and fragmented field size combined with an affordable price (Rabi *etal*., 2012).

In major areas of the world, farmers with small land-holdings are using Walking tractors. With the introduction of walking tractors in Bangladesh, some 30 years ago, a large number of farmers shifted from animal powered tillage system to mechanized farming. In 2009, there were 300'000 two-wheel tractors providing services in Bangladesh alone. In south Asia, small fields and affordable prices of walking tractors persuaded farmers to get rid of traditional plowing with bullocks and adopt Walking tractors. (Islam, 2009).

Single axle tractors with PTO powered rotary tiller have gained general popularity in cultivating rice paddies where the soil requires lower tractive power. On the other hand, soil tillage with drawn implements in rain fed farming exhibit two to eight times higher soil resistance than in wet rice paddy (HoltKamp *etal.*, 1990). Thus, it is advisable to restrict single axle tractors to light soil types and wait for correct timing of ploughing when there is ideal soil moisture at the beginning of wet season. There is different soil conditions in different areas thus; to restrict single axle tractor on light wet soil without checking types of soil is not preferable.

The implementation of walking tractors allows appreciably increasing the work performance as compared to manual work. At the same time, they note that the work with walking tractors relates to hard physical work. Physical load causes a rapid fatigue of the operator and unwanted stops to rejuvenate equipment. During the work on the tractor, the operator controls the course. By pulling, the operator tries to increase the tractor movement speed, thus increasing the performance; however, he gets tired fast and stops for a rest. This reduces the general tractor performance (S I Ovsyannikov, 2018).

The draught force of the walking tractor is generated by two energy sources: energy of the fuel combusted in the engine and operator's physical force. The operator spends physical forces for: ensuring the course (horizontally controlling the arms), providing agro technical tillage depth of the tractor (vertically controlling the arms), manual alteration of the tractor draught dynamics (axially controlling the arms), and stabilization to prevent the tractor overturning and walking over the tilled soil. The value of physical forces applied by the operator during tilling

by the walking tractor depends on a variety of factors, for instance, on physical training and conditioning of the operator, mass and geometry of the tractor (S I Ovsyannikov, 2018).

2.3 Experience of Other Countries in Customization of Two Wheeled Tractors

Researches have shown that, the current problem of mechanization in Ethiopia is similar to what was there in South and South East Asia such as Bangladesh, Thailand, Vietnam, and Sri Lanka, a few decades ago (Sheahan and Barrett, 2017). Even though the socio economic status in those times could be stated as reason for the rapid growth in number of tractors in Asia, the government policies toward utilizing locally manufactured tractors and suppliers of implements take the main role. In contrast, the high cost and unsuitability of imported machineries remained the major obstacles for sub Saharan Africa (SSA) countries (Baker, 2008).

In 1961, the number of tractors available in SSA (excluding South Africa) was much larger than what there was in Asia and Latine America. Soon after two decades, the number of tractors available in SSA started to decline by the 1990s (Dharmawardene, 2006). In 2000, Latine America and Asian countries such as Brazil, China and India have 3.7, 4.4 and 6.9 tractors as many as SSA while Thailand alone has as many tractors as SSA (Baker, 2008)

Bangladesh's agriculture, which relies on small machines such as two-wheeled tractors, is one of the most mechanized of South Asia, even beyond India's agriculture, which mostly is based on larger machines (Baudron *etal*. 2015). Since the government declared duty free imports of two wheeled tractors in 1995, the number of 2WTs raised to 100,000 units in 1996 from 5,000 units in 1989. Estimations indicate, an average rate of 60,000 units were being imported each year (International development Enterprise report, 2012). Even though the smallholder farmers own less than 0.65 hectare of land by average, which is less than Ethiopia's by half, the use of 2WTs have given an opportunity to mechanize the fragmented farm lands. In Bangladesh only in 2012, on an average of all locations, 69.9% area of the total cultivated land was under 2WTs (Baudron *etal*, 2015).

Appreciating and supporting local agricultural machineries manufacturers has helped Vietnam reach high level of mechanization. Vietnam has the most mechanized agriculture in Asia with about 900,000 agricultural machineries, 270,000 2WTs having engine capacity of less than 12Hp; out of this 85% is owned by smallholders (having less than one hectare of land), This

was achieved by Vietnamese manufacturers most of whom manufacturing 2WTs (Tuan, 2016). This South Asian model of mechanization appears equitable as even the poorest farmers have access to 2WT based services, which are cheaper than services using animal traction or 4WTs. This made the access to machines possible by the low cost of 2WTs, making their purchase possible for many farmers without support from a formal financial institution (Baudron *etal*. 2015).

There are many reasons for the farmers to purchase 2WTs. Some of these are, shortage of labor for land preparation, difficulty to care for bullocks, and shortage of draft power. After engaging 2WTs, the farmers become able to reduce labor cost, obtain easier and faster land preparation, obtain profits from selling bullocks, and plant timely (Quayum and Ali, 2012).

2.4 Usage of Walking Tractor in Ethiopia

Having gotten experiences of mechanization from South and Southeast Asian countries, Ethiopia has also started importing 2WTs in large numbers, with the number of units in use in the country estimated at 4,100 in 2014 (Baudron *etal*. 2015). Yet, the high cost and the low income per household has remained the bottleneck for the adoption of 2WTs and keeps the growth of agricultural mechanization too slow (Baudron *etal*. 2015). It was stated by the UNIDO that researches, technology adaptations and extensions have to be emphasized to transform farming from traditional to modern mechanization.

Furthermore, farmers should have local access to the inputs they need and supporting infrastructures for mechanization like, repair services, supplying spare parts, fuel and lubricants (UNIDO report, 2008).Demand for these machines, which typically have less than 15Hp, have rapidly raised by their lower cost compared to 4WTs, their greater maneuverability and ability to be fully utilized in systems with small landholdings, potential for off-farm use throughout the world (Takeshima and Silver, 2016). These machines have become the main mechanical power resources in small and medium size farms in southern and south eastern Asian countries. Recently, Ethiopia has started importing 2WTs. Agricultural Equipment and Technical Service Co. (AETS) and Adama Agricultural Machinery Industry (AAMI) are the main importers.

3 MATERIALS AND METHODS

3.1 Description of the Research Areas

This study was conducted in selected areas of Amhara region such as Machakel, Basoliben, Guzamen, Awabel, Bure and Libo kemkem districts from February 2021 to August 2021.

Machakel District is one of 18 districts of East Gojjam Administrative Zone. Amanuel is the capital of the district, which is located 328 kms from Addis Ababa and 228 kms from Bahir Dar. The agro ecological zone of the District was categorized as 54 % Woyina Dega (mid altitude), 37.7% Dega (highlands), 4% Wurich (alpine) and 2.3 % Kola (lowland).

Basoliben district is a triangular shaped district at the southernmost point of East Gojam. The capital of the district is yegube. The area has two agro climatic divisions: 54% lowland and 46% midland. Its altitude is ranges from 1500 to 2500 meters above sea level.

Guzamen district is found in the north western highlands of Ethiopia. Debremarkos is the capital of the district. It contains 25 rural kebeles. The district has three agro climatic zones namely, Dega (highland), Woyna Dega (mid altitude) and Kola (lowland). The district has an altitudinal difference of 1200-3510 meter above sea level. The average annual rainfall is 1628mm and its average temperature is 11^{o}C to 25^{o}C.

Awabel is one of the districts in Amhara Region of Ethiopia. Part of Misraq Gojjam Zone, Awabel is the capital of the district. The district has one urban and 19 rural kebeles, the district located 20km from Debremarkos, 290km from Bahir Dar and 280km from Addis Ababa.

Bure district is one of the districts found in West Gojam zone. Agro ecologically Bure is classified in to moist and wet lowland (10%), wet Woyna Dega (82%) and wet Dega (8%).The mean annual rainfall ranges from 1386 to 1757mm. the western and northern parts of the district receive relatively higher annual rainfall compared to other parts of the district. Its altitude and temperature ranges is from 713 to 2604 meters above sea level and 14^{0}C to 24^{0}C respectively.

Libo kemkem district is one of the district in Amhara region of Ethiopia. Part of the South Gonder zone, kemkem is boarded on the south by the Reb which separate it from fogera, on the west by Lake Tana, on the north by the North Gonder and on the east by Ebnat. Rivers in this district include the Arno and the Reb, which drain into Lake Tana. A survey of the land in

this district shows 51% is arable or cultivable, 8.3% pasture, 5.9% forest or shrubland, 17.98% covered with water and the remaining is considered degraded or others. Teff, corn, sorghum, cotton and sesame are major crops grown in this district.

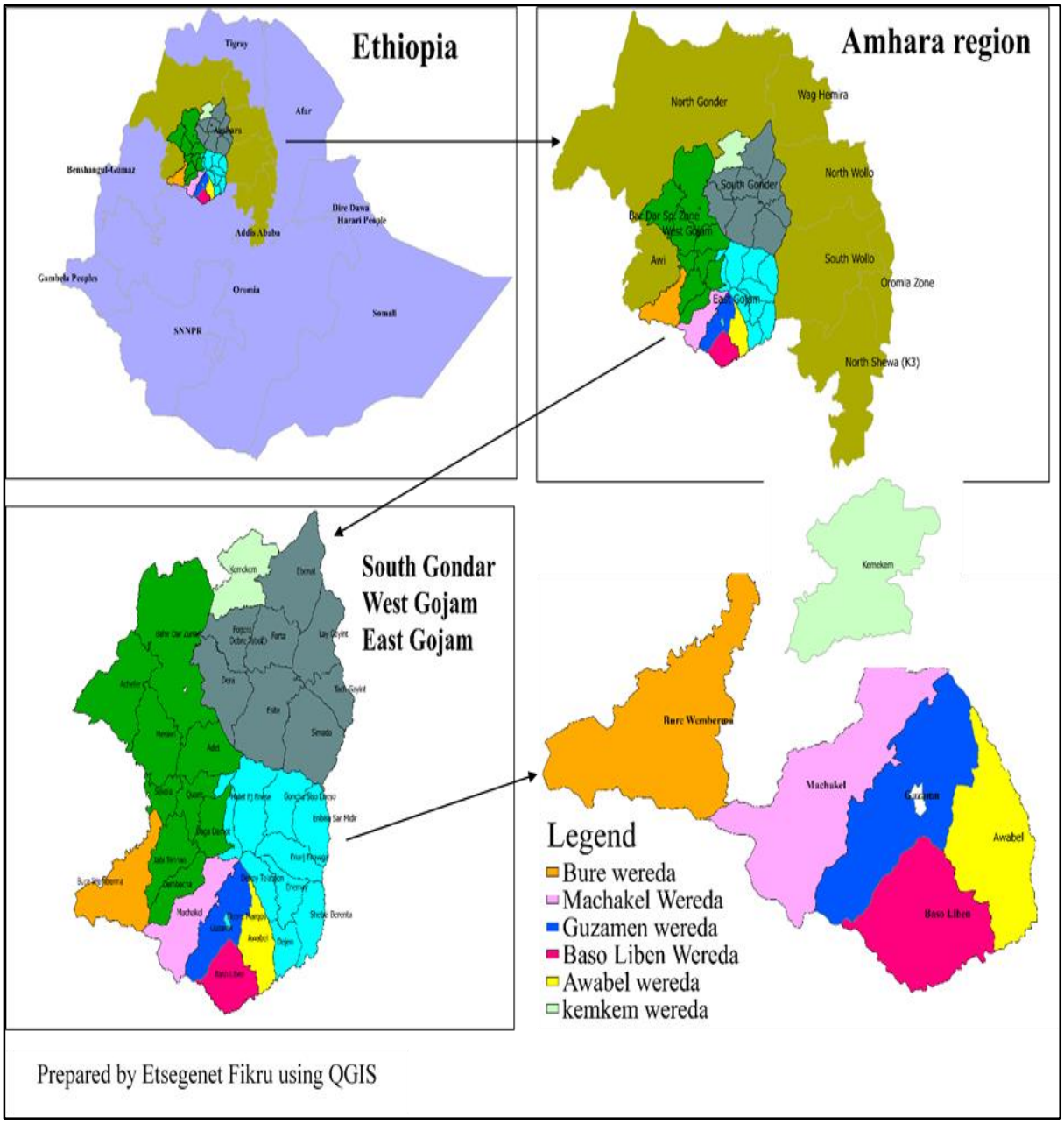

Figure 3-1: Study Areas Descriptions Map

3.2 Types of Data Collection

The data required for the investigation was used both primary and secondary data, which were collected for the successful accomplishment of this research. Secondary data were collected from internet, bureaus, offices, and literatures through document reading and note taking.

Primary data were collected from the selected sample respondents with structured questionnaires, key informants and focus group discussants.

The data concerning adoption and effectiveness of walking tractor at the research area was collected through structured questionnaire, interview, field observation, and focus group discussion, direct contact with ministry of agriculture mechanization directorate, CIMMYT directorate, SG directorate in Bahir Dar branch and Machakel, Basoliben, Bure, Awabel, Libo kemkem and Guzamen districts agricultural officers. The Field data's; include the size of the field, soil type, climatic condition, and infrastructures.

3.3 Research Design

Cross-sectional study design was conducted to assess effectiveness of the walking tractor in adoption to the targeted areas as well as to evaluate the current management system and assess the factors hindering the adoption of walking tractor. The study used primary and secondary sources of data. The relevant primary sources contain original, raw and unprocessed data. The relevant secondary data were collected from documents.

A survey on the overall effectiveness and status of walking tractor was conducted on six districts in south Gondar, east and west Gojam zones from February 2021 to August 2021. Primary data were collected through a structured questionnaire on selected respondent farmers regarding mainly different factors for effectiveness and adoption of walking tractors such as awareness, lack of skill, operation costs, information of soil type, topography, training for walking tractor users and spare part availability. The physical observation was also made on the current existing activities performed by walking tractor and records targeted district's agricultural office.

The research design generally an inductive process that used to assess different factors hindering adoption and effectiveness of walking tractors in Machakel, Basoliben, Bure, Awabel, Libo kemkem and Guzamen districts in Amhara region. The figure 3.2 shown below shows the work flow used in this research.

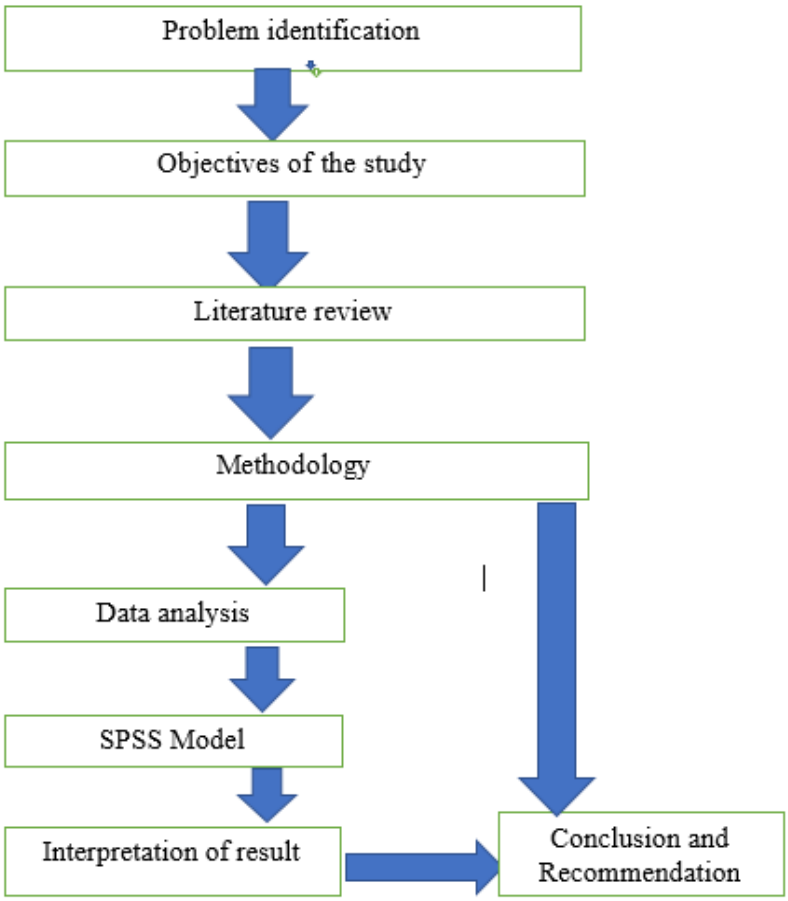

Figure 3-2: Work flow

3.4 Sample Size Determination

In this study sample size was determined by using single population proportion formula (Calculator.net, 2021)

$$n = Z\ (\alpha/2)^2\ p\ (1-p)/d^2 \quad \ldots\ldots (1)$$

Where:

- ✓ n = the sample size to be determined
- ✓ Z(α/2) = the standard normal deviate set at 1.96, which corresponds with the 95% confidence interval
- ✓ p = the estimated proportion in a population=50% (0.5)
- ✓ d = the proportion of sampling error between the sample and the population = 5% (0.05)
- ✓ So, to calculate sample size; $n=\frac{(1.96)^2\times 0.5\times(1-0.5)}{(0.05)^2}$
- ✓ n=384

- ✓ Adding 10% of non-response rate, then we get, n= 384 (1+0.1) =422

At district level, proportional sampling technique was employed to calculate the sample size based on number of kebeles having functional walking tractors. The required sample sizes at kebele level were equally allocated to each kebele. From the total sample size 26 respondents had a walking tractors. The detail distribution of sample size is expressed in table 3.1 shown below.

No of respondents at kebele = $\frac{Total\ Number\ of\ respondents}{Total\ number\ of\ kebeles}$……... (2)

No of respondents at kebele = $\frac{420}{12}$= 35

Equation 1. Sample size calculation at kebele level

No of respondent at district= No of kebeles x No of respondents at kebele…… (3)

Table 3-1: Sample size distribution in targeted districts

Districts	No of kebeles in the district	No of respondent in each kebele	Total no of respondent
Machakel	7	35	245
Guzamen	2	35	70
Basoliben	2	35	70
Awabel	1	35	35
Total	12	35	420

3.5 Sampling Technique

The study was employed by multistage sampling procedure. The primary sampling units were zones in the Amhara region and out of 11 zones, 3 zones namely east Gojam, west Gojam and south Gondar were selected by purposive sampling technique based on the presence of walking tractor. Secondly, a total of 6 districts; 4 district from east Gojam zone (Machakel, Basoliben, Guzamen and Awabel district), 1 district from west Gojam zone (Bure district), 1 district from south Gondar zone (libo kemkem district) were selected by purposive sampling technique based on the presence of walking tractor in the district. In the third sampling unit, 7 Kebeles from Machakel district, 2 Kebeles from Basoliben district, 2 Kebeles from Guzamen district and 1 Kebele from Awabel district were selected by purposive sampling technique based on the presence of functional walking tractor in the kebele. Tractors found in Bure and Libo

Kemkem districts were not functional and questioner survey were not conducted. Finally the required sample sizes were equally allocated to those selected kebeles which have functional walking tractor as indicated in figure 3.3 below.

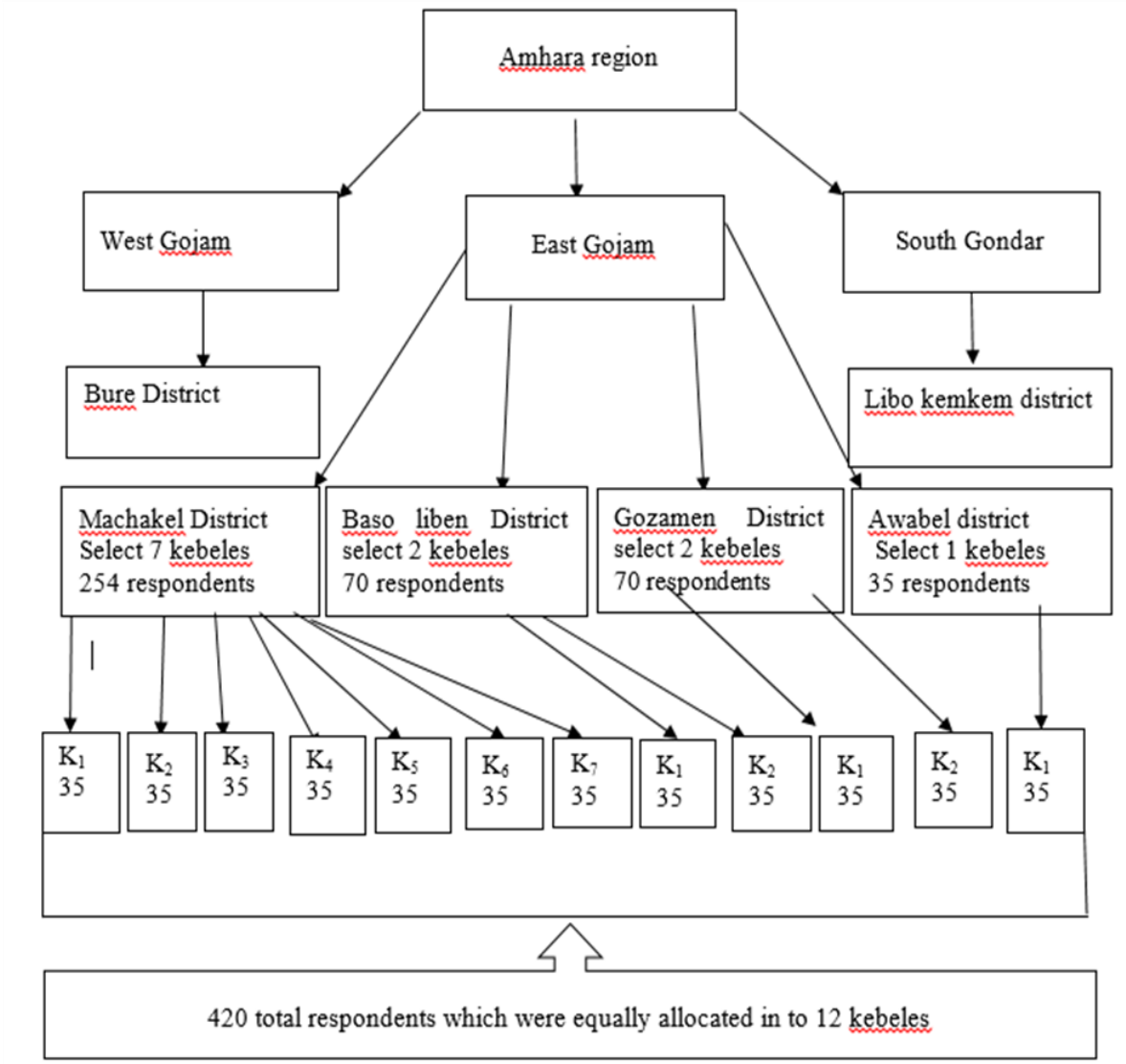

Figure 3-3: Schematic presentations of sampling procedure together with their equal and proportional allocations of sample size.

3.6 Data Analysis

A comprehensive questionnaire was designed to glean information from the farmers through one-to-one interviews, questioner and focus group discussion. The data obtained was analyzed using an analysis tool of a computer package. MS-Excel 2016 and Epi info version 7 were used for data entry and coding and SPSS Version 23 statistical software was used for analysis. The

validity of data collection tool was test using procedures such as by strongly monitoring data collectors, using other data collectors to reduce bias, screening the collected data if any unfilled questionnaires, appropriately put the collected data on data probing software including MS Excel, strongly monitoring data in crew and quality assurance and by checking the consistency testing and the validity of data collection tool.

Descriptive statistical design method were used for number of walking tractors in each district, interests of farmers for mechanization, purpose of crop production, distribution of walking tractors in targeted districts, availability of farm machinery, status of walking tractor, cost of walking tractor and ways of affordability of walking tractor by using table, chart and graph. Binary logistic regression was used to evaluate factors associated with adoption of walking tractors. Fishers exact test was used to evaluate factors associated with effectiveness of walking tractors. One way ANOVA was used to analyze the dependent factor plowing time with independent factors such as soil type and topography whereas plowing time, threshing time and threshing labor were analyzed using T- test by taking training as an independent factor to evaluate the effectiveness of walking tractor. In all analysis p value less than 0.05 were used as a statistical significance difference while in binary logistic regression 95% confidence interval not included 1 were used as an additional mechanism to say there were statistically significance difference.

4 RESULT AND DISCUSSION

4.1 Current status and practice of walking tractor

4.1.1 Interests of farmers for usage walking tractor

Farmers in all of the targeted districts were interested in walking tractor, and they had been renting walking tractor. However, owing to lack of road infrastructure in the Basoliben district, the availability of walking tractor for rental service was insufficient, although farmers were interested in utilizing walking tractor if they could get rental service. A small percentage of farmers were uninterested in purchasing walking tractor, some owing to lack of awareness, cost of walking tractor and others due to lack of training. According to the data collected in the targeted districts, 4.04 percent were not interested in walking tractor, 60.33 percent were interested, and 35.6 percent were highly interested, as shown in the pie chart below (figure 4.1). All stake holders should take responsibility for increasing farmer interest in walking tractor and supporting farming operations. The government, as the primary stake holder, was responsible for assisting businesses, facilitating finance options, and raising knowledge about walking tractor. On the other hand, the company has responsibility for enabling the delivery of spare parts and maintenance service centers near the farmers' homes.

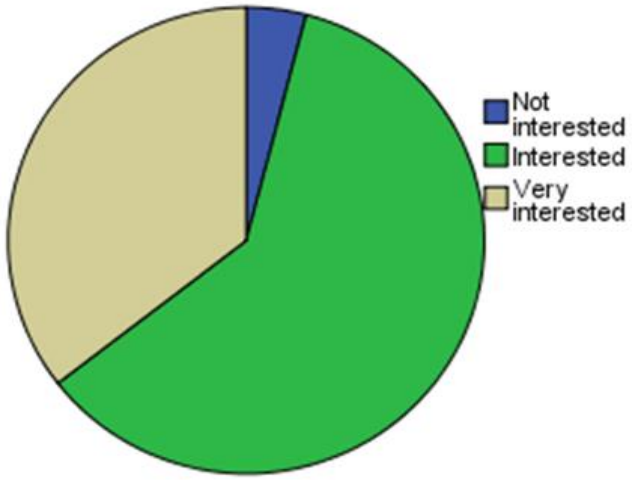

Figure 4-1: Percentage of interests of farmers towards usage of walking tractor

4.1.2 Purpose of crop production

According to the replies of respondent farmers in targeted districts, the majority of the farmers had a family size of 3 to 10 people and 0.5 to 5 hectares of land. The majority of farmers in all

districts indicated that they were farmed on their lands, while other farmers were given farms by contract with consent. Farmers were also given the opportunity to educate their family members. In general, 74.05 percent respondent farmers in all targeted areas grow the crop for food, of them produce the crop for food, 25% for food and market, and just 0.952 percent for market. Small amount of crop were produced for markets because of less usage of farm machinery in the study area. In the bar chart below, agricultural output in the targeted districts was presented (figure 4.2).

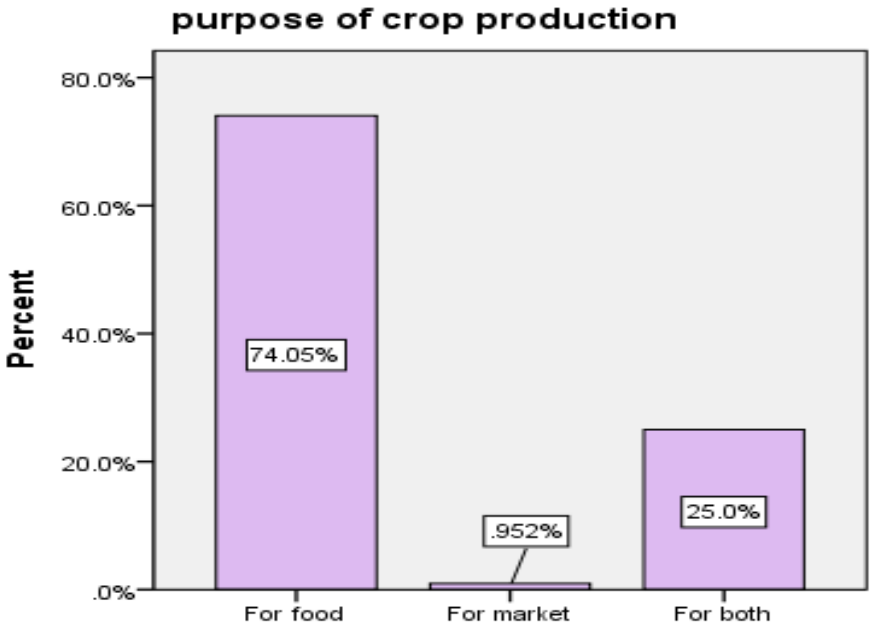

Figure 4-2: percentage of purpose of crop production

4.1.3 Availability of farm machinery

Due to the lack of tractor and other essential agricultural machinery, some farmers reported that their farm activities were frequently laborious. According to the acquired data, 17.55 percent, 31.43 percent, 15.71 percent, and 14.29 percent of respondents in Machakel, Basoliben, Gozamen, and Awable districts, respectively, claimed there was no delay in farm operation owing to non-availability of farm equipment. In the Machakel, Basoliben, Gozamen, and Awabel districts, respectively, 82.45 percent, 68.57 percent, 84.29 percent, and 85.71 percent of respondents reported there was a delay in farm operation owing to non-avalaiability of farm equipment's, as shown in figure 4.3.

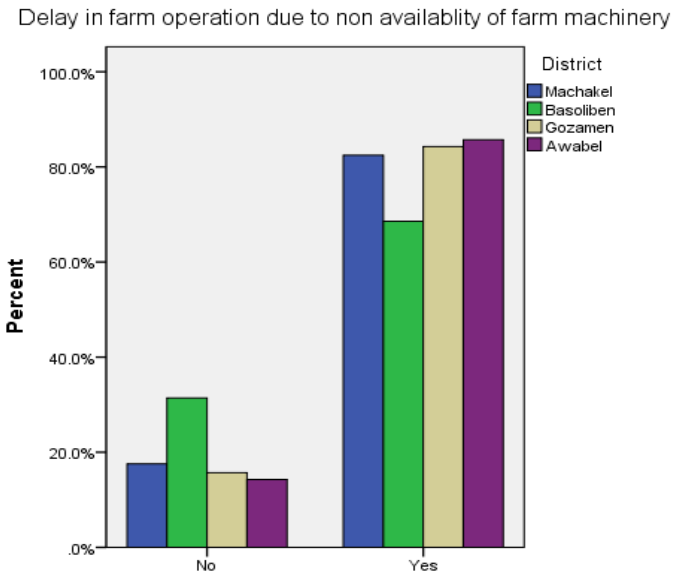

Figure 4-3: Percentage of delay in farm operation due to non-availability of farm machinery

4.1.4 Number of Walking Tractors in Targeted Districts

The number of walking tractors in the six surveyed districts such as Machakel, Basoliben, Guzamen, Awabel, Bure and Libo Kemkem were 19, 4, 2, 1, 7 and 2 respectively depending up on the districts agricultural office data distribution of walking tractors shown in figure 4.4 below.

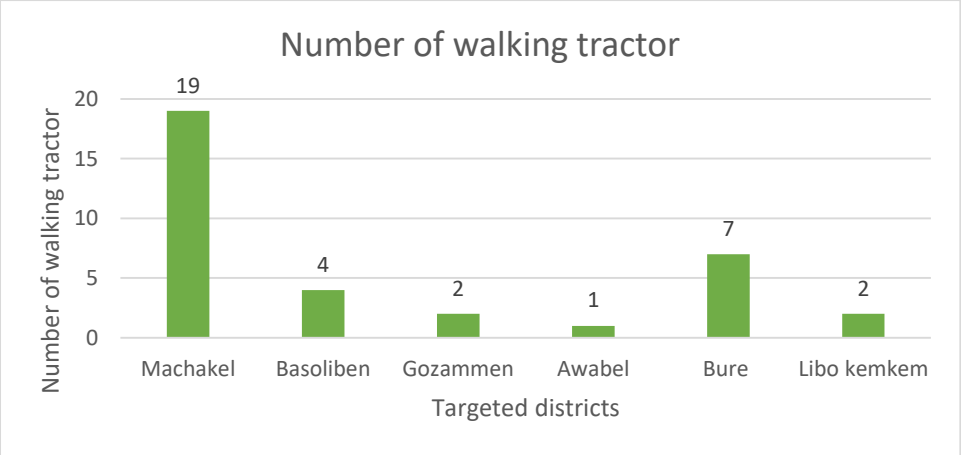

Figure 4-4: Number of walking tractors in targeted areas

4.1.5 Distribution of Walking Tractors in Targeted Districts

The walking tractors were distributed in targeted districts with different ways. One way of distribution was held by MoA, different organizations and projects work on mechanization

includes CIMMYT and SG. They import the walking tractors and distributed to the users in two different ways such as by giving freely as a promotion and by facilitate credit opportunity. MoA gave two walking tractors for Machakel, two for Libokemkem and one for Bure district. Whereas CIMMYT gave eight walking tractors for Machakel, one for Awabel and one for Guzamen district. There were also other projects distributed walking tractors such as GIZ, SG and AGP.GIZ gave six walking tractors for Bure district. SG gave two walking tractors for Machakel, one for Basoliben and one for Guzamen districts. AGP gave three walking tractor for Basoliben district. In Machakel district three users got the walking tractor by taking credit from Walya Credit Institution and the four users directly purchased from different importers. The data's stated above were gathered from targeted districts agricultural office.

4.1.6 Status of Walking Tractors in Targeted Districts

The number of functional walking tractors were 15, 2, 2 and 1 in Machakel, Basoliben, Guzamen and Awabel districts where as the number of non-functional walking tractors in Machakel, Basoliben, Bure and lebo-kemkem districts were 4, 2, 7 and 2 respectively. The main reasons for the non-functionality of the walking tractors in all districts were lack of training, lack of infrastructures, improper systems in governmental and non-governmental mechanization institutions to support the users, lack of operating skill, difficulty due to high vibration of walking tractor, failures of component parts of walking tractors with in short period of time, absence of spare part and maintenance services. Generally, by considering total walking tractors in all four targeted districts 43.75% were not functional and 56.25% were functional as indicated in the pie chart shown in figure 4-5 below.

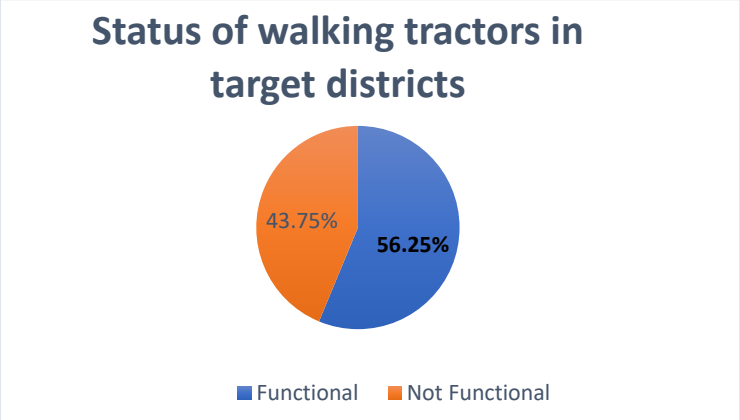

Figure 4-5: Functionality of walking tractors

4.1.7 Key Operations Performed by Walking Tractor

In the targeted districts the most common activities performed by the walking tractor users and the farmers who use walking tractor through rental service including ploughing, threshing, harvesting, transporting and water pump (figure 4.6). Harrowing was not commonly performed in the targeted areas. In machakel district compared with other targeted districts the farmers at the moment developed a positive attitude towards walking tractor and preferred walking tractor rather than traditional farming system.

The users of functional walking tractors in the four targeted districts stated that they got a number of advantages such as reduce time as compared to the previous traditional farming system, increase productivity, reduce labor during farming activities, generate income from rental service and avoid carousal during threshing. Due to the advantages the users of walking tractor accept the technology.

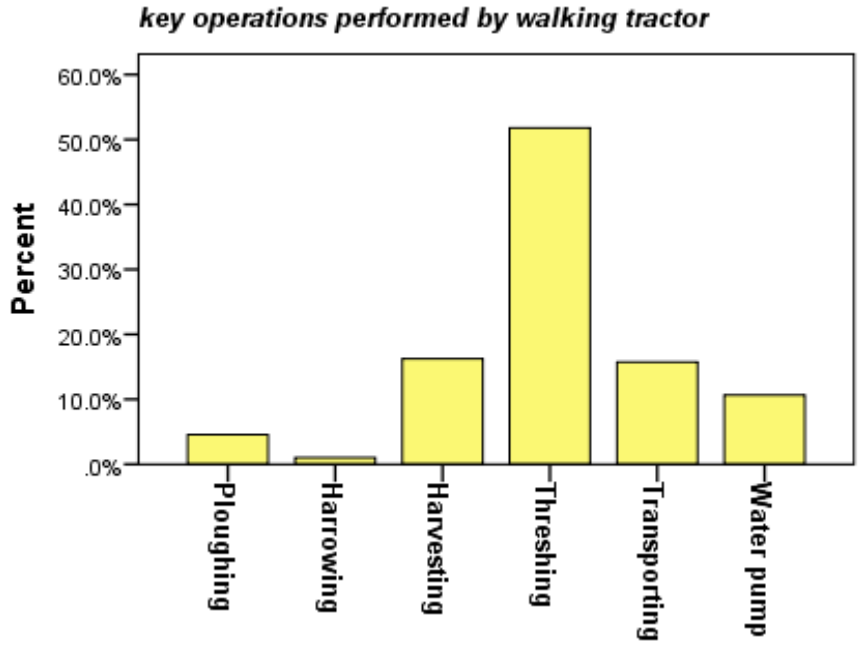

Figure 4-6: Percentage of different operations performed by walking tractor

In machakel district there were two planters donated from MoA, but two of them were not functional till April, 2013. The district sent one planter with mechanization professional to awash melkasa research center and the planter was modified and maintained. Now, after modification the farmers were used to plant wheat and it was successful. Machakel was the first district that used planter with walking tractor among the 4 targeted districts (figure 4-7).

Figure 4-7: Farmers at the time of planting wheat with planter and after plant growing

4.1.8 Walking Tractor Rental Service

The assessment of this study also showed that, the farmers that have had walking tractors gave rental service for other farmers in the targeted districts. In machakel district there was a good activity and the farmers also had a high demand to use walking tractors through rental service. In machakel, basoliben, Awabel and Guzamen districts the farmers had initiation and demand to use walking tractor by renting from plowing up to harvesting and transporting. The minimum and maximum number of farmers used one tractor for rental services were 18 and 140 respectively (table 4-1).

Table 4-1: Average number of farmers used walking tractor through rental service

	N	Minimum	Maximum	Mean	St.Devation
Tractor for rent	26	18	140	68.38	28.521

Comparatively in Machakel district a large number of farmers used walking tractor in rental service. However, at the time of the farmers gave rental service problems were occurred in different parts of the machineries such as walking tractor, thresher, water pump and trailers, to reduce those problems the farmers need capacity building training in operation, repair and maintenance.

At the time of visited, some functional walking tractors were given rental service for farmers who had not walking tractors in different agricultural practices such as ploughing, threshing,

harvesting and transporting. They generate income from rental activities and also they spend money for different actions like fuel cost, spa, for maintenance and spare part cost, and cost for mechanic, labor cost, oil cost and others. From those the walking tractor users spend more amount of money for maintenance, spare part and mechanic because there was no maintenance and spare part service and technical expert around their area. Therefore they take mechanic and spare part from Addis Ababa which takes high cost, needs more time and disturbs their rental service and it leads to decrease in income getting from rental service

Table 4-2: The mean difference between income and expense on rental service

	N	Mean	Mean difference
total income from rental service	26	54100.769	40532.923
total expense	26	13567.846	

The average income generated from rental service in one year was 54100.769 birr. While the average total cost used to walking tractor in a year was13567.846birr. This shows that using walking tractor for rental service is profitable. In addition to the execution of their farming activities rental service with a single walking tractor generates a profit of 40,532.923 birr per year averagely (table 4-2).

Generally at the time of group discussion most of the farmers used walking tractor through rental service and they stated that, using walking tractoszr had different advantages including;

- ✓ Minimizing time
- ✓ Avoiding carousal, in the time of traditional threshing activities the farmers prepare unwanted carousal, so using agricultural machinery avoid this extravagant activities.
- ✓ Reducing labor, in the time of traditional harvesting and threshing activities needs many farmers and animals to accomplish the process but the walking tractor works with one or two farmers and
- ✓ Increasing quality of product.

Whereas the owners of walking tractors blamed that they were face different problems during rental service activities including;

- ✓ Lack of spare part and maintenance service around their area
- ✓ Lack of technical experts to fix the problems

- ✓ Ritual days respect by the farmers also disturb the rental service, the farmers who live in the targeted districts do not work in ritual days which affects the schedule of rental activities.

4.2 Effectiveness of walking tractor

4.2.1 Comparison of Walking Tractor with Traditional Farming System

Table 4-3: Independent t-test analysis between animal and tractor

Variable	Factor	N	Mean	Mean difference	T	Sig
Plowing time	Animal	26	4.46	2.58	12.617	0.001
	Tractor	26	1.88			
Thresher time	Animal	26	6.46	4.96	22.92	0.000
	Tractor	26	1.50			
Threshing labor	Animal	26	4.327	1.942	17.933	0.002
	Tractor	26	2.385			

The average days for plowing one hectare of land with animal was 4.46 and the average days for plowing one hectare of land with walking tractor was 1.88. This shows that there was decrease in days required to plowing after using walking tractor. Basically the result indicates that using walking tractor reduced time of plowing by 2.58 days averagely. The average hours for threshing one quintal of crop with animal and human labor was 6.46 hrs. While the average hours for threshing one quintal of crop with thresher was 1.50hrs. This specifies that there was a 4.96 hrs decrease in hours by using thresher for threshing crops.

The average number of labors for threshing one quintal of crop in traditional threshing system was five. While the average number of labor for threshing one quintal of crop with thresher was two. This designates that there was a decrease in labor by using thresher for threshing crops. In addition to this in traditional threshing system the farmers prepare a huge carousal to laborers in participating threshing process. The thresher avoids this unwanted extravagant in threshing system.

According to independent t-test analysis, the mean plowing time ($p=0.001$), the mean threshing time ($p=0.000$) and the mean thresher labor ($p=0.002$) between animals and Walking tractor

were significance. These indicated that tractor was more effective for plowing and threshing than traditional farming system (table4.3).

4.2.2 Comparison of trained and non-trained Walking Tractor users

Table 4-4: Independent t-test analysis between farmers who get training and did not get training

Variable	Factor (training)	N	Mean	Mean difference	T	Sig
Plowing with tractor	No training	12	2.67	0.46	2.513	0.019
	Get training	14	2.21			
Tractor for rent	No training	12	54.42	-23.726	-2.28	0.032
	Get training	14	78.14			
thresher time	No training	12	1.708	0.3869	2.767	0.011
	Get training	14	1.321			
thresher labour	No training	12	2.542	0.3274	2.535	0.018
	Get training	14	2.214			

According to independent t-test analysis, the mean plowing time with tractor (p=0.019), the walking tractor users who did not gained training averagely used 2 and half days to plow 1 hectare of land. Whereas the users who gained training use 2 and quarter days to plow 1 hectare of land. According to thresher time, the walking tractor users who didin't gained training used averagely above 1 and half days (1.70) to thresh one hectare of crop with thresher. Whereas the users who gained training averagely used 1 and half days to thresh 1 quintal of crop and the mean threshing time with tractor between users who gained and did not gained training (p=0.011) were significance. During threshing time the users who gained training use 2 laborers while users who did not use averagely 3 laborers to thresh one hectare of crop and the mean thresher labor required with tractor (p=0.018) between farmers who get training and farmers who did not gain training were significance. The walking tractor users also give rental service, the users who gained training give averagely for 80 farmers in one season. Whereas the users who did not gained training give averagely for 54 farmers and the mean farmers used rental service required with tractor (p=0.032) between farmers who get training and farmers who did not gain training were significance. Based on the result shown in the above (table4.4), farmers who get training were used Walking tractor effectively than farmers who hadn't gain training.

4.2.3 Comparison on effectiveness of walking tractor in different soil type and topography

Table 4-5: One way ANOVA analysis of soil type

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3.045	2	1.522	11.507	0.002*
Within Groups	9.923	75	0.132		
Total	12.968	77			

Table 4-6: Least significant difference method (LSD) of the three soil types

Type of soil	Type of soil	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Red soil	sandy soil	-0.28846 *	0.10088	0.005 *	-0.4894	-0.0875
	black soil	-0.48077 *	0.10088	0.001*	-0.6817	-0.2798
sandy soil	black soil	-0.19231	0.10088	0.060	-0.3933	0.0087

*The mean difference is significant at the 0.05 level.

The one way ANOVA test analysis between the three soil types showed that the mean plowing time was significant (p= 0.002) (table 4.5). Based on Multiple Comparisons test i.e the least significant difference method (LSD) the mean significance difference were between red soil type and sandy soil type (p= 0.005); red soil type and black soil type(p= 0.001) while there was no significance difference between sandy soil type and black soil type (p= 0.060). These result indicated that walking tractor were more effective in red soil type than sandy and black soil type in the research area(Table 4.6) and this result was in line with the previous study conducted by HoltKamp *et al.* (1990) in Netherland.

Table 4-7: One way ANOVA analysis of topography

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3.045	2	1.522	10.995	0.001*
Within Groups	10.385	75	0.138		
Total	13.429	77			

Table 4-8: Least significant difference method (LSD) of topography

Type of topography	Type of topography	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Plain	Hilly	-0.28846 *	0.10320	0.007 *	-0.4941	-0.0829
	Dipping	-0.48077 *	0.10320	0.002*	-0.6864	-0.2752
Hilly	Dipping	-0.19231	0.10320	0.066*	-0.3979	0.0133

*The mean difference is significant at the 0.05 level.

The one way ANOVA test analysis between the three topography types showed that the mean plowing time was significant (p= 0.001) (table 4.7). Based on Multiple Comparisons test of the least significant difference method (LSD) the mean significance difference were shown between plain topography and hilly topography (p= 0.007); plain topography and dipping topography (p= 0.002) while there was no significance difference between hilly topography and dipping topography (p= 0.066). These result indicated that Walking tractor were more effective in plain topography than hilly and dipping topography (table 4.8)

4.3 Factors Hindering Effectiveness of Walking Tractor

This study was conducted to express the factors affecting effectiveness of walking tractors like training, topography, soil condition, operation of walking tractor and level of difficulties in the time of failures. The results obtained from the fisher exact test on the factors affecting effectiveness are shown in table 4.9 below.

Table 4-9: Factors affecting effectiveness

Variable	Effectiveness		Fishers Exact test
	Ineffective	Effective	P – value
Training			
No training	7	5	0.038
Get training	2	12	
Topography			
Disagree	1	11	0.014
Agree	8	6	
Soil condition			
Disagree	2	12	0.038
Agree	7	5	
Difficulty due to failure			
Low level of difficulty	3	13	0.046

High level of difficulty	6	4	
Simplicity of operation			
Disagree	2	7	0.418
Agree	7	10	

The fisher's exact test revealed that there was a significant association between effectiveness with different variables such as training, soil condition, topography and difficulty due to failure of parts of walking tractor. The respondents who get training were more effective than that of respondents who didn't got training (P=0.038). The numerical value indicates that the higher number of walking tractor users gain training and states that the walking tractors were effective. Topography and soil condition also affect effectiveness of walking tractor with P- value 0.014 and 0.038 respectively. Most farmers stated that walking tractor were effective in red soil type and plain topography so that one way ANOVA analysis on soil type (table4.6) and topography (table 4.8) approved the statements of farmers. Another factor level of difficulty during failure of part of walking tractor was significant association between effectiveness (P=0.046). During farming activities with walking tractor high level of difficulties were occurred that leads to failures of machineries and it was not solved by users.

The other factors for effectiveness of walking tractor in all targeted districts was absence of maintenance and spare part service around their area. This makes a high impact on effectiveness of walking tractors. The result in table 4-10 showed that there was no maintenance and spare part service in all walking tractor users (100%).

Table 4-10: Frequencies for maintenance and spare part

Variables	Frequencies (%)	
	No (%)	Yes (%)
Maintenance service availability around users area	26 (100)	0 (0)
Spare part availability around users area	26 (100)	0(0)

The walking tractor users face problem on parts of walking tractor and they take mechanic from Addis Ababa or they go to Addis Ababa for maintenance and spare part service. This process takes a high duration of time which directly related with delay in farm operation. Whereas the performance of machinery affected due to walking tractor and implements are

frequently failed. The other problem of walking tractor users in all targeted districts were that mostly unaware of the operation and maintenance schedule of their machine and equipment.

At the time of study in Bure and Libo kemkem districts all walking tractors were not distributed to the users. The agricultural office of Bure and Libo kemkem districts stated that there were different reasons and these the following were the main one;

- ✓ Lack of willingness to distribute walking tractor
- ✓ high vibrations on walking tractors during operations
- ✓ Lack of operating skill
- ✓ Fearing of strength of soil type found in the area (Black cotton soil).

Due to the above listed and other reasons 7 walking tractor in bure and 2 walking tractors in Libo kemkem district were non-functional. According to the other district income gained from walking tractor, a single walking tractor generates a profit of 40,532.923 birr per year from rental service. Based on this data wastages on the non-functional walking tractor were 283, 730.461 birr per year in Bure and 81065.846 birr per year in Libo kemkem district respectively. In terms of man power if one walking tractor given to 3 Young's they creates work opportunities to 21 young's in Bure and 6 young's in Libo kemkem district who have not work around the area. This opportunity were failed in Bure and Libo kemkem districts due to non-functional walking tractors. Finally, non-effective walking tractors in this district affects the farming technology transfer plan to the farmers in the area.

Generally during group discussion the respondent stated that the major factors for effectiveness of walking tractor in targeted areas were;

- Lack of maintenance service
- Lack of supply of spare part
- Lack of training related to walking tractor
- Walking tractor components fails, there is no technical expert who could fix the problems
- There was no attention given for walking tractor users especially from districts agricultural extension workers.

4.4 Adoption of Walking Tractor

Table 4-11: Univariable and multivariable logistic regression analysis of adoption

Variable	Adoption		COR	AOR	P-value
	Yes	No	95% CI	95% CI	
Education level					
Illiterate	19	180	RF	RF	
Adult education	32	130	2.332 (1.266-4.295)	2.292 (1.002-5.245)*	0.049
Above primary school	53	6	83.684 (31.800-220.225)	42.303 (10.744-166.556)***	0.000
Land Size					
< 1 hectare	5	96	RF	RF	
1-1.9 hectare	58	151	7.375 (2.856-19.044)	3.595 (0.787-16.411)	0.099
>= 2 hectare	41	69	11.409 (4.288-30.356)	6.430 (1.311-31.528)*	0.022
Training					
Yes	17	2	30.678 (6.954-135.345)	17.223 (1.725-171.928)*	0.015
No	87	314	RF	RF	
Farmers use tractor by rent					
Yes	76	102	5.695 (3.477-9.326)	3.537 (1.439-8.690)**	0.006
No	28	214	RF	RF	
Affordable					
Yes	56	28	12.000 (6.945-20.736	2.539 (1.060-6.080)*	0.037
No	48	288	RF	RF	
Reasonable					
Strongly disagree	14	198	RF	RF	
Disagree	10	97	1.458 (0.625-3.401)	.487 (0.157-1.517)	0.215
Agree	54	19	40.195 (18.929-85.355	9.425 (3.659-24.276)***	0.000
Strongly agree	26	2	183.857 (39.535-855.021)	14.857 (2.122-104.034)**	0.007

NB:-* statistical significant variables at $p < 0.05$, ** statistical significant variables at $p < 0.01$, *** statistical significant variables at $p < 0.001$, Hosmer and Lemeshow test 0.913, RF=references

A binary logistic regression analysis was conducted both in univariable and multivariable aspects in order to identify the relationship between factors that affects adoption of walking tractors. Following the control of other variables, the association of various independent variables with the adoption of walking tractors was observed. Factors like, education status of respondents, land size, training related to walking tractor, rental service by walking tractor, affordable cost for walking tractors, and reasonable cost for two-wheel tractors have had a statistically substantial link to variable outcome (adoption)(table 4-11).

The level of education was significantly related to willingness to adopt walking tractor, where participants who had primary and above education levels were forty two and more times (AOR=42.303, 95% CI: (10.744-166.556)), more likely to adopt walking tractor than the illiterates as well as participants who had adult education were two and more times (AOR=2.292, 95% CI: (1.002-5.245)), more likely to adopt walking tractor than illiterates.

Another factor land size were significantly associated to adopt walking tractor, in which participants who have land size of greater than two hectares were six and more times more likely to adopt walking tractor than those who have less than one hectare of land (AOR= 6.430, 95% CI: (1.311-31.528)) this result was in line the previous study conducted by (Rabi *etal*., 2012).

Respondents who gained training about walking tractor were seventeen and more times (AOR =17.223, 95% CI :(1.725-171.928)), more likely and have more interests to adopt walking tractor than that of respondents who didn't gain training. Different governmental and non-governmental organizations who have responsible for mechanization gives training for farmers before purchasing walking tractors and creates motivation for farmers to adopt walking tractor. Unless if they didn't get training they assume the operation of walking tractor is very difficult and also didn't have interest to adopt walking tractors.

Participants who use walking tractor through rental service had three and more times to adopt walking tractor than those who didn't use walking tractor by renting at (AOR= 3.537, 95% CI: (1.439-8.690)).The farmers who use walking tractor through rental service knows different advantages of walking tractor and have high interests to adopt walking tractors but the farmers who didn't use walking tractor by renting were not knows advantages of walking tractor. Mechanization professionals take home work from federal up to kebele levels on awareness creation about walking tractors.

Participants who would afford the price of walking tractors were two and more times more likely to adopt walking tractors than those who could not afford at (AOR =2.539, 95 % CI:(1.060-6.080)).The government works with different agricultural machinery importers to reduce the cost of walking tractors by encouraging the importers to import walking tractors tax free and the government controls importers to sale walking tractors by acceptable costs and facilitate credit service for farmers.

Participants who strongly agree on the reasonable cost of the two-wheel tractor were fourteen and more times (AOR=14.857,(95% CI: (2.122-104.034)) more likely to adopt walking tractor than those who strongly disagree with the reasonable cost of the two-wheel tractor whereas Participants who agree on the reasonable cost of the two-wheel tractor were nine and more times (AOR=9.425, 95% CI:(3.659-24.276))more likely to adopt walking tractor than those who strongly disagree. While other factors like sex, age, occupation, Farming experience, Farming involvement soil type and topography were not significantly associated with the adoption of walking tractor and this result was in line with the previous study conducted by Baudron *et al*. (2015).

One of the influential factor for adoption of walking tractor to farmers was cost of walking tractor. In the targeted districts most of the respondents said that the cost was expensive. The respondents that said the cost was cheap, affordable, expensive and very expensive with the percent's 6.635%, 17.3%, 25.36% and 50.713% respectively (figure 4-8). This result indicates that minimize walking tractor cost leads to changing the traditional farming system to mechanization and appreciate small scale farmers to use farming technology. By sharing experience from other countries like Bangladesh (Baudron *etal*, 2015), one way of reducing the cost of walking tractor was the government import the walking tractors tax free.

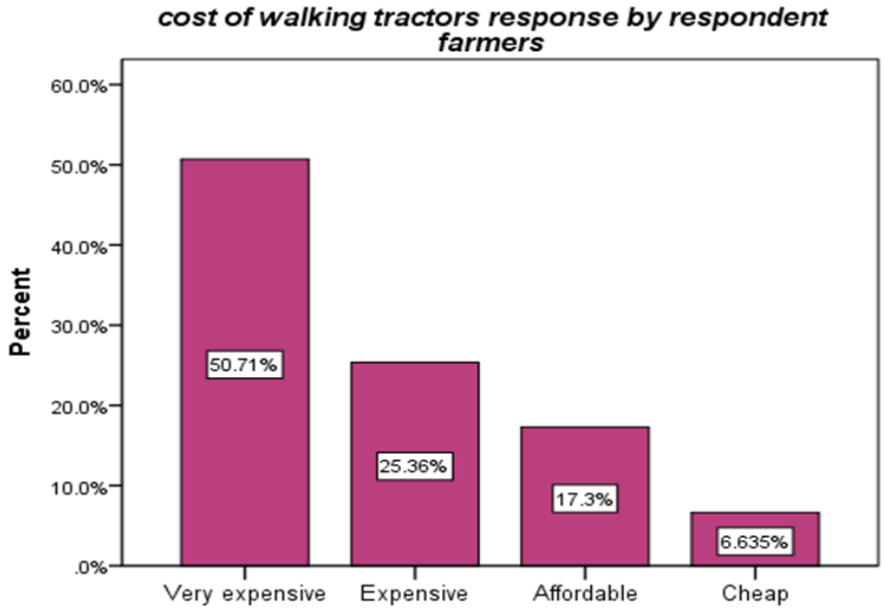

Figure *4-8*: cost of walking tractors expressed by respondent farmers

To develop mechanization technology, the question was that in what way could increase affordability of the machineries The response of the respondents were shown in the figure 4.9 below stated that 32.8% purchased by group, 58.21% purchased by credit and the rest 8.974% purchased by a combination of both to afford the cost of walking tractors.

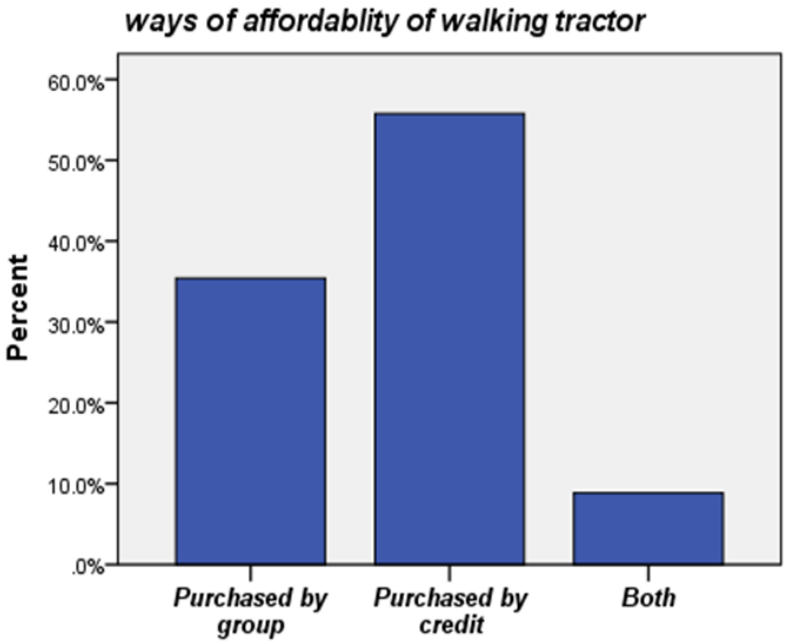

Figure 4-9: ways of affordability of cost of walking tractors

Additionally unavailability of maintenance and spare part also create high impacts on adoption of walking tractors, the frequency table (table 4.10) prepares based on response of walking tractor users because it was directly related to users and all users' response indicates there was no maintenance and spare part service around their area. some respondent farmers who have large number of land size that afford cost of walking tractors have high interests to adopt walking tractors but they claimed on absence of spare part and maintenance service around the area. Some respondents also have high interests to adopt walking tractors but they states there was no supplier of walking tractor in the targeted area. Ministry of agriculture mechanization directorate and different mechanization organizations take their responsibilities by working on to solve different factors affecting adoption of walking tractors and create opportunity for farmers to develop mechanization. Walking tractor importers also import spare parts of walking tractors because some walking tractor users states that they didn't get spare parts of walking tractors in the market.

Generally during focus group discussion the respondents stated that the main causes for adoption of walking tractor in all three targeted districts includes;

- ✓ Lack of awareness creation about walking tractor
- ✓ Lack of proper maintenance and supply of spare part
- ✓ Lack of proper skill and knowledge of machinery
- ✓ Lack of commitment on agricultural sectors
- ✓ Cost of walking tractor

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusions

This research work presents adoption and effectiveness of walking tractors in Amhara region with six targeted districts such as Machakel, Basoliben, Guzamen, Awabel, Libo kemkem and Bure.in this districts walking tractor gives different purposes for farmers and create good instigation on farmers to use different agricultural machineries. In this finding, plowing one hectare of land with walking tractor needs an average of two and half days as compared to plowing with animal which takes an average of seven days this means that walking tractor reduce an average of five days of plowing time While, threshing one quintal of crop with thresher reduced average of 7.23hrs as compared to threshing with animal and human labor. In addition to the execution of their farming activities rental service with a single walking tractor generates an average profit of 40,532.923 birr per year.

The walking tractor users who got training decrease an average of 0.46 days plowing time as compared to farmers who did not get training about walking tractor. Whereas, 0.4 days of thresher time were decrease users who got training as compared to who did not get training. During threshing time the users who got training use 2 laborers while users who did not got training use 3 laborers to thresh one hectare of crop. The walking tractor users also gave rental service, the users who got training give averagely for 78 farmers in one season which is higher than users who did not got training give averagely for 54 farmers.

There was a significant association between effectiveness with different variables such as training, soil condition, topography and difficulty due to failure of parts of walking tractor. Among different types of soil in the study area, red soil type decrease an average of 0.28 days and 0.48 days plowing time as compared to sandy and black soil type respectively. The mean significant difference were between red soil and sand soil type; red soil type and black soil type While, in among different topography plain area decrease an average of 0.28 days and 0.48 days plowing time as compared to hilly and dipping topography.

Factors such as limited training, absence of spare part and maintenance can affect adoption and effectiveness of walking tractor. Respondents who got training about walking tractor were twelve and more times, more likely to adopt walking tractor as well as effectively use the walking tractor than that of as compared to respondents who didn’t gain training so that

facilitating training access to the farmers play an important role in familiarize and effectively utilize the technologies. Availability of spar part and maintenance service nearby the districts will increase the adoption and effectiveness of the walking tractor. Other factors such as education level, land size, and cost of walking tractor hinder adoption process. Participants who had adult education as well as primary and above education levels were better chance to adopt Walking tractor than illiterates. This implies that educate illiterates will support farmers for adoption of walking tractors. Participants who have land size of greater than two hectares were seven and more times more likely to adopt walking tractor than those who have less than one hectare of land.

5.2 Recommendations

Based on the above conclusion and limitation of this study the following recommendations are forwarded:-

- ✓ Preparing training about walking tractor to the users with a period of interval of time.
- ✓ Facilitating spare part and maintenance service to the users near the area to increase the functional period of walking tractors.
- ✓ In addition to walking tractor the importers should import spare parts to give access to the users.
- ✓ Different walking tractor importers open their outdoor services to district level, prepare promotion on walking tractor for farmers and give repair and maintenance service. So farmers can buy in cash or installment and effectively use walking tractor.
- ✓ Walking tractor importers import walking tractors with testing and quality certification of agricultural machinery that will help to build farmers confidence and enhance usage of walking tractor.
- ✓ Agricultural machinery marketing companies, banks and other financial institutions provide collateral free credit to farmers.it is necessary for the growth of agricultural mechanization and to increase users of walking tractor in the country.
- ✓ Accessibility of farm roads and off road important for mechanized farms, this is also important for effectiveness of walking tractors.
- ✓ Providing mechanization professionals in each districts.
- ✓ The agricultural offices in each districts should establish a real walking tractor management systems:

- ✓ Performance evaluation should be done on walking tractors found in Bure district either distribute to the farmers or replace by other walking tractors.

The following recommendations are suggested for future work:

- ✓ Further study should be done on performance evaluation of walking tractor based on different type of soil.
- ✓ Further study should be done on design modification of threshers with in the targeted areas.

References

Agricultural Mechanization Forum Ethiopia (2018). Technical brief. https://agrilearning-ethiopia.org/wp content/uploads/ 2015/10/AKLDP_ Agri_Mech_Tech_brief.pdf

Ali Mohammed Ibrahim Zayan. (2005). Evaluation of farm machinery management system in Guneid sugar scheme (Sudan). Faculty of Agriculture University of Khartoum.

ATA annual report (2015). Agricultural transformation agenda Annual Report. In agricultural transformation agenda Annual Report (p. 14). https://doi.org/http://dx.doi.org/10.1155/2015/165165

ATA strategy (2014). Ethiopian National Agricultural Mechanization Strategy. Retrieved from https://agriknowledge.org/downloads/ks65hc24x

Baker, D. (2008). Agricultural mechanization in sub-Saharan Africa : time for a new look. Rome: FAO. http://www.fao.org/3/a-i0219e.pdf

Baudron, F., Sims, B., Justice, S., Kahan, D. G., Rose, R., Mkomwa, S., Gérard, B. (2015). Re-examining appropriate mechanization in Eastern and Southern Africa: Walking tractors, conservation agriculture, and private sector involvement. *In Food Security* (Vol. 7, pp. 889–904). https://doi.org/10.1007/s12571-015-0476-3

Brian Sims 1, and Josef Kienzle (2016). Agricultural Engineer, Plant Production and Protection Division, Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, Rome 00153, Italy; Josef.Kienzle@fao.org

CIMMYT (International maize and wheat improvement center) (2014). Farm mechanization and conservation Agriculture for sustainable intensification (facasi) project. Market analysis for small mechanization .Ethiopia. October, 2014.

EIAR (Ethiopian Institute of Agricultural Research ((2017). Workshop jointly organized by IFPRI, CIMMYT and the Ethiopian agricultural forum. Ethiopia. November 2017.

Esdaile, R. J. (2012). Walking tractor newsletter. Tamworth NSW Australia

Faleye, T.; Adebija, J.A. and Farounbi, A.J. (2012). Improving small-farm productivity through appropriate machinery in Nigeria. *Int. Res. J. Agric. Sci. Soil Sci*., 2, 386–389.

FAO (2006). Agricultural mechanization policy and strategy formulation: Sudanese technical report, TCP SV 445. FAO of UN, Rome, Italy. (2) pp: 552.

Gebresenbet, G., & Kaumbutho, P. G. (1997). Comparative analysis of the field performances of a reversible animal-drawn prototype and conventional mould board ploughs pulled by a single donkey, 40, 169–183.

Getachew, S. (2020); Design development and testing of two wheel tractor. http://hdl.handle.net/123456789/10957

Goe M.R. (1997); Influence of slope and stone cover on tillage operations in Ethiopian highlands. Soil & tillage research 49(1999) 289-300

Guush (2014). Ethiopian agriculture is mainly rain fed with two rainy seasons: June-September (Meher season) and February May (Belg season). The country's total arable land is 74 Million hectares haring Development Experiences June 18-19, 2014 Beijing, China.

Haque, M. E., R. W. Bell, A. K. M. S. Islam, K. Sayre and M. M. Hossain. (2011). Versatile Multi-crop Planter for walking Tractors: an innovative option for smallholders. Proc. 5th World Congress of Conservation Agriculture. Brisbane, Australia. Indonesia: Michigan State University.

Haque, M. E.; Bell, R.W. (2015) Development of machinery for smallholders in South and South East Asia. In Presented in Workshop on Modern Conservation Farming Systems and CIMMYT Science Week, Lanzhou, China.

Holtkamp Rodolf Lorenz and Jim (1990). Technical Center for Agricultural and Rural Cooperation (Ede, Netherlands). Small Four Wheel tractors for the Tropics and Subtropics: their role in Agricultural and Industrial Development. Deutsche Gesellschaftfür Technische Zusammenarbeit(GTZ); Weikersheim: Distributed by Magraf, Eschborn

International development Enterprise report (2012). Study into the commercialization of selected agricultural machines in Bangladish. https://repository. cimmyt.org/ xmlui/ bitstream/handle/10883/3394/98527.pdf

Islam, S. (2009). Farm mechanization for sustainable agriculture in Bangladesh – problems and prospects. J. of Agril. Mach. & Mech. 4(1): 77-85.

Jonathan Kuje Yohanna Ango, Usman Fulani and Williams Aka'ama(2011) . A Survey of Mechanization Problems of the Small Scale (Peasant) Farmers in the Middle Belt of Nigeria .Journal of Agricultural Science .Vol. 3, No. 2; June 2011

Maamun, M. Y. (1984). Aspects of land preparation mechanization in South Sulawesi, Indonesia in consequences of small farm mechanization in Indonesia. By Kasryno. F.et al. AARD, Dir. Gen. for Food Crops and IRRI.

Melaku (2011). Oxenization versus Tractorization: Options and Constraints for Ethiopian Framing System.International Journal of Sustainable Agriculture 3 (1):11-20, 2011

Melese T.92017). Conservation of tillage systems and water conservation productivity. Implication of small holder farmers in Semi-Arid Ethiopia., 20 Feb, 2017.

Mohammed Siddig Mohammed A. (2015). A computer program for agricultural machinery costestimation. Unpublished M.Sc. Thesis. University of Science and Technology of Sudan.

Negrete, Jaime Cuauhtémoc (2014). Rural poverty and agricultural mechanization policies in Mexico. *Journal of Agriculture and Environmental Sciences*.3:45–66.

Omer, A.M.I., (2013). Effect of Tillage Implements type on field performance parameters and some soil Properties in Belail area (s.Darfur).

Quayum, M. A., & Ali, A. M. (2012). Adoption and diffusion of power tiller in Bangladesh. In Bangladesh *Journal of Agricultural Research* (Vol. 37, pp. 307–325).

Rabi GR (2012). Research on Maize and Wheat No Tillage Seeder for walking Tractor, Unpublished PhD thesis, College of Engineering, China Agricultural University, Beijing, China.

Rasool, S., & Raheman, H. (2018). Improving the tractive performance of walking tractors using rubber tracks. Biosystems Engineering, 167, 51–62. https://doi.org/10. 1016/j.biosystemseng.2017.12.013

RDAO, (2007).Population and housing census usual resident of household in a given region, zone, district and kebele in 2007.

Sakai, (2009). J. Principles of Walking Tractor Plowing and Design Theories of Japanese Plows, J. JSAM Kyushu Section (30), 1990, 38-46.

Sam, B., & Kathirvel, K. (2006). Vibration Characteristics of Walking and Riding Type Power Tillers. Biosystems Engineering, 95(4), 517–528. https://doi.org/10.1016/j .biosystemseng.2006.08.013

Sample size calculator. (Available at: .https://www.calculator.net/. Accessed on January 20, 2021)

Sheahan, M., & Barrett, C. B. (2017). Ten striking facts about agricultural input use in Sub-Saharan Africa. Food Policy, 67, 12–25. https://doi.org/10.1016/j.foodpol.2016 .09.010

Shridar, B., P. K. Padmanathan, and R. Manian. (2009) 'Utilization Pattern of Power Tillers in Tamil Nadu.' Agricultural Mechanization in Asia, Africa & Latin America 37(1): 85-89.

Sims, B.G.; Kienzle, J. and Hilmi, M (2016). Agricultural Mechanization: A Key Input for SubSaharan African Smallholders; Food and Agriculture Organization of the United Nations: Rome, Italy; in press

Sims, B.G.; Kienzle, J.; Mkomwa, S.; Friedrich, T.; Kassam, A.H. (2006) Mechanization of smallholder conservation in Africa: Contributing resilience to precarious systems. In Conservation Agriculture for Africa. Building Resilient Farming Systems in a Changing Climate; Kassam, A.H., Mkomwa, S., Friedrich, T., Eds.; CAB International: Oxford, UK; Boston, MA, USA, 2017; pp. 183–213.

Singh, S. (2014). Farm mechanization in hills of uttarakhand, India a review. Agriculture for Sustainable Development 2(1): 65-70.http://gilgitbaltistan.gov.pk/gbvalley

Tadesse. (2014). the Marginalized and Poorest in Different Communities and Settings of Ethiopia Draft, April, 2014

Takeshima, H., and Silver, J. (2016). Agricultural Mechanization and Agricultural Transformation Agricultural Mechanization and Agricultural Transformation.

Temesgen M., Hoogmoed W.B., Rockstrom J., Savenije H.H.G. (2009). Conservation tillage implements and systems for smallholder farmers in semi-arid Ethiopia. Soil & tillage research 104(2009) 185-191

UNIDO report (2008). Agricultural mechanization in Africa... Time for action. ------ https://www.unido.org/sites/default/files/2009.05/agricultural_mechanization_in_Africa_0.pdf Website: http://www.eiar.gov.et

Y.S Ademiluyi, A. Ozoemena Ani,+ B.O. Ugwuishiwu+ and O.A. Oyelade(2008), National Centre for Agricultural Mechanisation (NCAM)/2008.07/, Ilorin Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka

Annexes

Annex 1. English version Questioner for users

Identification _____

Name of district/District: _____

Sex of respondent, 0. Female 1. Male

Age of respondent

Education status of respondent: 0. Illiterate 1. Adult education 2. Primary School 3. Secondary school 4. Diploma 5. Degree

Occupation of respondents 0. Farmer 1. Merchant 2. Others

Farming experience (Years): 0. <10years 1. 10-20 years 2. >= 20years

Farming involvement: 0. No involvement 1. Part time 2: Full time,

What is your family size?

Is there access to education for your family? 0. No 1. Yes

1. What is your land size in hectare?
2. What type of crop are produced on your land?
3. How much time to carry out one hectare of land plowing with animals? (Hours)
4. For what purpose producing crop? 0. For food 1. For market 2. Both
5. Are there market access for your product? 0. No 1. Yes
6. If there are agricultural machineries around your area, do you want to them for your farming practice? 0. No 1. Yes
7. Have you ever heard about 2 wheel tractor 0. No 1. Yes
8. If your answer for question 7 is yes from where do you heard?
   0. From colleague 1. From extension workers …. 2. From mass media 3. From governments 4. From different projects
9. What key operation normally carried out with the walking tractor?
10. Is there any farmer in your village using walking tractor? 0. No 1. Yes
11. Do you have Walking tractor? 0. No 1. Yes
12. If your answer is Yes for Q 11, how many walking tractor do you have?
13. If your answer is No for Q 11, why not you purchase?
14. How do you get your tractor? 0. Own purchased …1. Donated 2. Both
15. If you get walking tractor by donation, who donates?
    0. MoA 2. CIMMYT 3. GIZ 4. SG
16. Is the price of walking tractor affordable for you? 0. No 1. Yes

17. If your answer is no for Q 16, in what way the cost will be affordable?

    0. Purchased by group 1. Purchased by credit 2. Both

18. How much is the capacity of your walking tractor/s in hp?

19. Who operate the walking tractor? 0. Yourself 1.operator

20. If implements for 2-wheel like drills, tiller and zero till drills and cart available, would you buy? 0. No 1. Yes

21. If you have not walking tractor, could you use by rent? 0. No 1. Yes

22. Is the cost you paid for rent of walking tractor for different purposes reasonable? 0. No 1. Yes

23. Would you list different purposes that you use by walking tractor?

24. How much time to carry out one hectare of land plowing with walking tractor? (Hours)

25. How much time to carry out one quintal of crop with laborers in hour?

26. How much time to carry out threshing one quintal of crop with thresher in hour?

27. How many laborers required to thresh one quintal of crop with labor and animal in a day?

28. How many laborers required to thresh one quintal of crop with thresher in a day?

29. Do you use your walking tractor for rent? 0. No 1. Yes

30. How many farmers used your walking tractor for rent?

31. How much money do you ask for your tractor for harvesting a hectare of crop?

32. How much money do you ask for your tractor for threshing a hectare of crop?

33. How much money do you ask for your tractor for transport a hectare of crop?

34. Is walking tractor rent for different purposes profitable? 0. No 1. Yes

35. Do you get training related to walking tractor? 0. No 1. Yes

36. If your answer for Q 35, is yes from where you get training?

    0. Dealers 1. Extension workers 2. Projects 3. All

37. Do ever the operation delayed due to non-availability of the machinery0. No 1. Yes

38. What problem you have to face in the hilly areas as compared to plain areas?

39. Describe the level of difficulty when using walking tractors?

    0. No difficulty 1. Low difficulty 2.Medium difficulty ……..3. High difficulty

40. What is the frequent problem you faced when using the walking tractor?

41. How do you control the problem you faced?

42. Machinery repair facility availability in the village? 0. No 1.Yes

43. If your answer for Q 42, is no then how far you have to go for machinery repair (km)

44. Machinery spare part facility availability in the village? 0. No 1.Yes

45. If your answer for Q44, is no then how far you have to go for machinery spare part (km)
46. How do you transport the implement of walking tractor from your home to working place or from field to field?
47. Do you prefer walking tractor as compared to your previous trend? 0. No 1. Yes
48. The cost of walking tractor is reasonable
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
49. Walking tractor can be used under different soil condition
    0. Strongly disagree 1.Disagree 2. Agree 3.Strongly agree
50. Walking tractor can be used under different topography
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
51. The operation of walking tractor is simple 0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
52. The dealer gives advice and training regarding usage of walking tractor
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
53. The dealer gives maintenance service nearby your area
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
54. I can maintain the tractor myself
    0. Strongly disagree 1. Disagree 2. Agree 3.Strongly agree
55. Using walking tractor is profitable
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
56. I recommend others to purchase walking tractor
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
57. Walking tractor needs operator seat
    0. Strongly disagree 1. Disagree 2. Agree 3. Strongly agree
58. How much time to carry out one hectare of land plowing with walking tractor in red soil? (hours)
59. How much time to carry out one hectare of land plowing with walking tractor in sand soil? (hours)
60. How much time to carry out one hectare of land plowing with walking tractor in black soil? (hours)
61. How much time to carry out one hectare of land plowing with walking tractor in plain area? (hours)

62. How much time to carry out one hectare of land plowing with walking tractor in hilly area? (hours)
63. How much time to carry out one hectare of land plowing with walking tractor in hilly area? (hours)

Annex 2. Amharic version Questioner for users

ክፍልአንድ: የተጠያቂዉ ግለሰብ ማህበራዊ እና ስነ-ህዘባዊ መረጃዎች

መለያ ቁጥር

የሚኖሩበት ወረዳ

ጾታ 0. ሴት 1. ወንድ

እድሜ (በቁጥር ያስገቡ)

የትምህርት ደረጃዎት? 0. ያልተማረ 1. የጎልማሶች ትምህርት 2. የመጀመሪያ ደረጃ 3. ሁለተኛ ደረጃ

የስራ ሁኔታዎት? 0. ገበሬ 1. ነጋዴ 2. ሌላ ካለ ይገለፅ

በግብርና የስራ ልምድዎት በአመት?
0. 0-10 አመት 1. ከ 10-20 አመት 2. ከ 20 አመት በላይ

በግብርና ስራ ላይ ያለዎት ተሳትፎ? 0. ምንም ተሳትፎ የለኝም 1. በከፊል እሳተፋለሁ 2. ሙሉ በሙሉ እሳተፋለሁ

የቤተሰበዎ ብዛት በቁጥር?

ለቤተሰብዎ በአቅራቢያ የትምህርት ተደረሽነት አለ? 0. የለም 1. አለ

ክፍል ሁለት፡ አጠቃላይ መረጃ

1. የእርሻ መሬት ስፋት በሄክታር?

2. በእርሻ ቦታዎ የሚያመርቱት ምርት 0. ጤፍ 1. ስንዴ 2. ባቄላ 3. አተር 4. ሁሉም 5. ሌላ ካለ ይገለፅ

3. የሚያመርቱትን ምርት ለምን አላማ ያመርታሉ?
0. ለምግብ ፍጆታ ብቻ 1. ለሽያጭ ብቻ 2. ለምግብና ለሽያጭ

4. አንድ ሄክታር የእርሻ መሬት በበሬ ለማረስ ስንት ሰአት ይፈጅበዎታል?

5. ምርትዎትን የሚሸጡበት ገበያ በአካባቢዎት አለ 0. የለም 1. አለ

6. ስለ ባለ ሁለት ጎማ ትራክተር ሰምተው ያውቃሉ? 0. አልሰማሁም 1. አወ

7. ለጥያቄ ቁጥር 6 መልስዎ አዎ ከሆነ ከየት ነው የሰሙት? 0. ከጓደኛ 1. ከግብርና ባለሙያ 2. ከመገናኛ ብዙሀን 3. ከመንግስት 4. ከተለያዩ ፕሮፐጀክቶች

8. በባለ ሁለት ጎማ ትራክተር ምን ሊሰራ ይችላል?

9. በአካባቢዎ ባለ ሁለት እግር ጎማ ትራክተር የሚጠቀም አርሶ አደር አለ?
0. የለም 1. አዎ

10. ባለ ሁለት ጎማ ትራክተር አለዎት? 0. የለኝም 1. አዎ

11. ለጥያቄ ቁጥር 10 መልስዎ አዎ ከሆነ ስንት ባለ ሁለት ጎማ ባትራክተር አለዎት?

12. ባለ ሁለት ጎማ ትራክተር እንዴት ነው ያገኙት?
0. ገዝቸ 1. በድጋፍ 2. በድጋፍና ገዝቸ

13. ትራክተሩን በድጋፍ ከሆነ ያገኙት በድጋፍ የሰጥዎት ማን ነው?
0. ግብርና ሚኒስቴር 1. ሲሚት 2. ጀ ኤ ዜድ 3. ኤስ ጅ

14. የትራክተርዎ አቅም በፈረስ ጉልበት ስንት ነው?

15. ባለ ሁለት ጎማ ትራክተሩን የሚያንቀሳቅሰው ማን ነው? 0. እራስዎ 1. የሰለጠነ ባለሙያ

16. ባለ ሁለት ጎማ ትራክተር ከሌለዎት ገዝተው ለመጠቀም ፈቃደኛ ነዎት?
0. አይደለሁም 1. አወ

17. ገዝተው ለመጠቀም ፈቃደኛ ካልሆኑ ለምን?

18. የባለ ሁለት ጎማ ትራክተር የመግዛት አቅም አለዎት? 0. የለኝም 1. አዎ

19. የመግዛት አቅም የለኝም ካሉ በምን መንገድ ቢገዛ ይሻላል ይላሉ?
0. በቡድን መግዛት 1. በብድር በግዛት 2. በቡድንም በብድርም መግዛት

20. ባለ ሁለት ጎማ ትራክተር ላይ የሚገጠሙ መሳሪያወች ልክ እንደ ማረሻ፣መከስከሻ፣ ማጨጃ እና ማንጎሪያ ብታገኝ መግዛት ይፈልጋሉ? 0. አልፈልግም 1.እፈልጋለሁ

21. ባለ ሁለት ጎማ ትራክተር ከሌለዎት በኪራይ ይጠቀማሉ? 0. አልጠቀምም 1. አወ

22. ለባለ ሁለት ጎማ ትራክተር ኪራይ የሚከፍሉት ብር ተገቢ ነው ብለው ያምናሉ?
0. አላምንም 1. አወ

23. በባለ ሁለት ጎማ ትራክተር የሚሰሩትን ስራ ቢጠቅሱልኝ?

24. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ ስንት ሰአት ይፈጅበዎታል?

25. ባለ ሁለት ጎማ ትራክተር ካለዎት ያከራዩታል? 0. አላከራይም 1. አወ

26. ባለ ሁለት ጎማ ትራክተርዎን ስንት አርሶአደሮች ይከራዩዎታል?

27. ባለ ሁለት ጎማ ትራክተር ማከራየት ትርፋማ ያደረጋል? 0. አያደርግም 1. አወ

28. አንድ ሄክታር መሬት ላይ ያለ ሰብል ለመሰብሰብ ስንት ብር ያስከፍላሉ?

29. አንድ ሄክታር መሬት ላይ ያለ ሰብል ለመውቃት ስንት ብር ያስከፍላሉ?

30. አንድ ሄክታር መሬት ላይ ያለ ሰብል ለማጓጓዝ ስንት ብር ያስከፍላሉ?

31. ባለሁለት ጎማ ትራክተርን በተመለከት ስልጠና አግኝተው ያውቃሉ?
0. አላውቅም 1. አወ

32. ስለ ባለሁለት ጎማ ትራክተር ስልጠና አግኝተው ከሆነ ስልጠናውን የሰጠዎት ምን ነው? 0. ባለሁለት እግር ትራክተር ሻጮች 1. የግብርና ባለሙያዎች 2. በአካባቢ የሚሰሩ ፕሮጀክቶች 3. ሁሉም አካላት

33. ዘመናዊ የእርሻ መሳሪያወች ባለመኖራቸው ምክንያት የእርሻ ስራ መስተጓጎል አጋጥሞወት ያዉቃል ወይ? 0.አያዉቅም 1.ያዉቃል

34. ከሜዳማ ቦታዎች አንፃር በኮረብታማ ቦታዎች ምን ችግር ያጋጥመዎታል?

35. ባለሁለት ጎማ ትራክተር ሲጠቀሙ የሚያጋጥመዎትን ችግር እንዴት ይገልፁታል? 0. ምንም አያጋጥመኝም 1. ትንሽ ችግር 2. መካከለኛ ችግር 3. ከፍተኛ ችግር

36. ባለሁለት ጎማ ትራክተር ሲጠቀሙ በተደጋጋሚ የሚያጋጥመዎት ችግር ምንድን ነው

37. የሚያጋጥመዎትን ችግርእንዴት ይፈቱታል?

38. በአካባቢዎ የባለሁለት ጎማ ትራክተር የጥገና ማዕከል አለ? 0. የለም 1. አወ

39. በአካባቢዎ የጥገና ማዕከል ከሌለ ለማስጠገን ምን ያህል ይጓዛሉ?

40. በአካባቢዎ የባለሁለት ጎማ ትራክተር መለዋወጫዕቃ አለ? 0. የለም 1. አወ

41. በአካባቢዎ መለዋወጫ ዕቃ ከሌለ ለማምጣት ምን ያህል ይጓዛሉ?

42. ባለሁለት ጎማ ትራክተርዎን ከቤት ወደስራ ቦታ እና ከስራ ቦታ ወደ ሌላ የስራ ቦታ እንዴት ይወስዱታል?

43. በባለሁለት ጎማ ትራክተር ማረስ ከባህላዊ አስተራረስ ዜዴ ይመርጡታል? 0. አልመርጠውም 1. አወ

44. የባለሁለት ጎማ ትራክተርዋጋ ምክንያታዊ/ተመጣጣኝ ነው? 0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

45. ባለሁለት ጎማ ትራክተርን በተለያየ የአፈር አይነት ላይ መጠቀም ይቻላል? 0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

46. ባለሁለት ጎማ ትራክተርን በተለያየ የመሬት አቀማመጥ ላይ መጠቀም ይቻላል? 0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

47. የባለሁለት ጎማ ትራክተርን አጠቃቀም ቀላል ነው? 0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

48. ባለሁለት ጎማ ትራክተር ሻጮች ስለአጠቃቀሙ ምክርና ስልጠና ይሰጣሉ?
0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

49. ባለሁለት ጎማ ትራክተር ሻጮች የጥገና አከልግሎት በአቅራቢያው ይሰጣሉ?
0. በፍፁም አልስማማም 1. አልስማማም 2. እስማማለሁ 3. ሙሉ በሙሉ እስማማለሁ

50. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በ ቀይ አፈር ላይ ስንት ሰአት ይፈጅበዎታል?

51. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በአሸዋማ አፈር ላይ ስንት ሰአት ይፈጅበዎታል?

52. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በ በጥቁር አፈር ላይ ስንት ሰአት ይፈጅበዎታል?

53. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በ ተራራማ አካባቢ ላይ ስንት ሰአት ይፈጅበዎታል?

54. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በ ሜዳማ አካባቢ ላይ ስንት ሰአት ይፈጅበዎታል?

55. አንድ ሄክታር የእርሻ መሬት በባለ ሁለት ጎማ ትራክተር ለማረስ በ ሸለቃማ አካባቢ ላይ ስንት ሰአት ይፈጅበዎታል?

Annex 3. Questioner for woreta agricultural research center

1. What is your main focus area in agricultural mechanization??
2. Do you have any program to introduce agricultural mechanization to small scale farmers?
3. What are the tasks which are performed on your center?
4. Is there any opportunities for the farmers facilitated by your center to use different farm machineries?
5. How did you see the attitude of farmers toward mechanization?
6. How do you see status of mechanization in Amhara region?
7. How do you encourage farmers to use farm machinery?
8. Do you have any program to test, verify and modify machineries and implements imported?
9. Is there any feedback you gathered from farmers, suppliers and agricultural Burea? If your answer is yes from which area?
10. Do you give training for walking tractor users?
11. Is there any study conducted in your center in relation to walking tractor? If your answer is yes would you please indicate the major findings of the study?
12. Do you think the type of soil in Amhara region have direct impact on walking tractor?
13. Have you gathered problems from walking tractor users? If your answer is yes list the problems?
16. How to support farmers who have a walking tractor?

Annex 4. Questioner for targeted districts agricultural bureau

1. What types of soil widely exist in your district?
2. What are the major crops grown in your district?
3. Is there any opportunities for the farmers to use different farm machineries in your district?
4. How did you see the attitude of farmers toward mechanization?
5. How do you see status of mechanization in your district?
6. How do you encourage farmers to use farm machinery?
7. How do you encourage farmers who have walking tractor?
8. How many walking tractors are there in your district?
9. How do you see interests of farmers for walking tractor?
10. Are the farmers are productive of using the walking tractor as compared with traditional farming system?
11. Do you think the type of soil in your district have direct impact on walking tractor?
12. Have you gathered problems from walking tractor users? If your answer is yes list the problems?

Annex 5. Questioner for walking tractor importers

1. What are total number of walking tractors imported by your company?
2. What are different brand or model of walking tractor you imported?
3. Which model of walking tractor you imported got the best sale?
4. Would you please mention the cost of all walking tractors you imported based on their model and horse power?
5. Have you give manual for the users?
6. Have you give training for farmers on walking tractors?
7. Do you have service center for your customer nearby the farm area?
8. What are the total number of walking tractors distributed to farmers?
9. What kinds of implements do you give with the tractors to the farmers?
10. How to distribute walking tractors for the farmers?
11. Do you know how many tractors are currently with end user or farmers?
12. If your answer is yes for question 11 would you please estimate the number?
13. Have you gathered problems from walking tractor users?
14. If your answer for question 14 is yes, please list down the problem?
15. From which regions and zones you received many problems?
16. Which model of walking tractor got more complain?

Annex 6. Questioner for Sasakawa Global

1. What is your main focus area in agricultural mechanization?
2. Do you have any program to introduce agricultural mechanization to small scale farmers?
3. Do you have soil classifications of the country?
4. What are the total number of walking tractor distributed by your own organization and in which area? _
5. What are the type or mode of walking tractor you distributed?
6. Would you please mention the cost of walking tractor based on their model and horse power?
7. What kind of implements do you give with walking tractors to the farmers?
8. How to distribute walking tractor and list the criteria's you need during distribution?
9. Do you know how many walking tractors are currently with end users or farmers?
10. Have you give training for farmers on walking tractor?
11. Have you gathered feedback or problems from walking tractor users?
    If your answer is yes please list down the problem and from which region and zone and from which model you received many complain?
12. Do you have any document (journal, books, reviews and videos) on walking tractor?
13. Is there any study conducted in your center in relation to walking tractor? If your answer is yes would you please indicate the major findings of the study?

Annex 7. Questioner for CIMMYT

1. What is your main focus area in agricultural mechanization?
2. Do you have any program to introduce agricultural mechanization to small scale farmers?
3. Do you have soil classifications of the country?
4. What are the total number of walking tractor imported by your own organization?
5. What are the type or mode of walking tractor you imported?
6. Would you please mention the cost of walking tractor based on their model and horse Power?
7. Which model of walking tractor you imported got the best sale?
8. What are the total number of walking tractors you distribute to farmers?
9. What kind of implements do you give with walking tractors to the farmers?
10. How to distribute walking tractor and list the criteria's you need during distribution?
11. Do you know how many walking tractors are currently with end users or farmers?
12. Have you give training for farmers on walking tractor?
14. Have you gathered feedback or problems from walking tractor users?
15. If your answer is yes please list down the problem and from which region and zone and from which model you received many complain?
16. Do you have any document (journal, books, reviews and videos) on walking tractor?
17. Is there any study conducted in your center in relation to walking tractor? If your answer is yes would you please indicate the major findings of the study?

Annex 8. Questioner for MoA

1. What is the level of experience of Ethiopia on agricultural mechanization?
2. What are your present and future plan about agricultural mechanization in Ethiopia?
3. Does your sector support the development of agricultural mechanization? If your answer is yes how to support?
4. Do you have any document on soil classification of the country?
5. What are the total number of walking tractor imported and distributed by your sector?
6. What are the total number of walking tractors you distribute to farmers?
7. What kind of implements do you distribute with walking tractors to the farmers?
8. How to distribute walking tractor and list the criteria's you need during distribution?
9. Do you know how many walking tractors are currently farmers?
10. Have you give training for farmers on walking tractor?

Annex 9. Income and expense cost from rental services

District	Walking tractor users	Harvested land in ha	Total Birr for harvesting	Threshing crop in quintal	Total birr from threshing	Total farmers use walking tractor for threshing and harvesting	Total birr from harvesting and threshing	Cost	Profit
Machakel	1.	1.75	2000	150	111600	87	113600	33384	80216
	2.	0.75	1050	132	102400	78	103450	27015	76435
	3.	0.75	1100	180	135200	87	136300	35385	100915
	4.	-	-	108	92350	77	92350	20185	72165
	5.	-	-	63	53400	31	53400	33000	20400
	6.	-	-	85	90000	60	90000	30000	60000
	7.	-	-	38	30000	62	30000	9800	20200
	8.	-	-	72	93400	76	93400	14500	78900
	9.	2	2500	162	122000	82	124500	38500	86000
	10.	1.25	1800	71	95600	68	97400	18800	78600
	11.	1.75	2100	42	43300	32	45400	12200	33200
Basoliben	12.	-	-	105	100800	88	100800	23600	77200
	13.	-	-	135	111320	79	111320	13650	97670
Guzamen	14.	1	1000	115	103400	65	104400	22750	81650
	15.	-	-	61	65000	45	65000	10870	54130
Awabel	16.	1.5	2100	41	43200	51	45300	9125	36175

Annex 10. SPSS analysis out put

Univarable binary logistic regression analysis (crude odds ratio)

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Education			80.945	2	.000			
Education(1)	.847	.312	7.381	1	.007	2.332	1.266	4.295
Education(2)	4.427	.494	80.415	1	.000	83.684	31.800	220.225
Constant	-2.249	.241	86.889	1	.000	.106		
Landsize			23.828	2	.000			
Landsize(1)	1.998	.484	17.041	1	.000	7.375	2.856	19.044
Landsize(2)	2.434	.499	23.771	1	.000	11.409	4.288	30.356
Constant	-2.955	.459	41.496	1	.000	.052		
Usebyrent	1.740	.252	47.767	1	.000	5.695	3.477	9.326
Constant	-2.034	.201	102.414	1	.000	.131		
Training	3.424	.757	20.437	1	.000	30.678	6.954	135.345
Constant	-1.283	.121	112.224	1	.000	.277		
Reasonable			132.454	3	.000			
Reasonable(1)	.377	.432	.761	1	.383	1.458	.625	3.401
Reasonable(2)	3.694	.384	92.420	1	.000	40.195	18.929	85.355
Reasonable(3)	5.214	.784	44.212	1	.000	183.857	39.535	855.021
Constant	-2.649	.277	91.768	1	.000	.071		

Multivarable binary logistic regression analysis (Adjusted odds ratio)

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Reasonable			41.862	3	.000			
Reasonable(1)	-.719	.579	1.540	1	.215	.487	.157	1.517
Reasonable(2)	2.243	.483	21.598	1	.000	9.425	3.659	24.276
Reasonable(3)	2.698	.993	7.385	1	.007	14.857	2.122	104.034
Training	2.846	1.174	5.878	1	.015	17.223	1.725	171.928
Usebyrent	1.263	.459	7.585	1	.006	3.537	1.439	8.690
Affordable	.932	.446	4.373	1	.037	2.539	1.060	6.080
Landsize			5.632	2	.060			
Landsize(1)	1.279	.775	2.727	1	.099	3.595	.787	16.411
Landsize(2)	1.861	.811	5.263	1	.022	6.430	1.311	31.528
Education			28.710	2	.000			
tEducation(1)	.830	.422	3.860	1	.049	2.292	1.002	5.245
Education(2)	3.745	.699	28.683	1	.000	42.303	10.744	166.556
Constant	-5.170	.820	39.731	1	.000	.006		

a. Variable(s) entered on step 1: catreasonable, cattraining, catusebyrent, cataffordable, catlandsize, catEducation.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	3.316	8	.913

Average income and expense

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
total income from rental service	26	.0	136300.0	54100.769	9763.8559	49786.0918
total cost	26	.0	38500.0	13567.846	2619.3581	13356.1581
Valid N (listwise)	26					