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Comparative Advantage of Tractor Utilization in Southeastern Oromia, Ethiopia.

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ABSTRACT*: This study analyze effect of tractorization on cropping intensity, crop yields and adoption of major agricultural inputs, on human labor employment, determine the utilization and per unit cost of tractor power according to the farm size, compare the different costs and profits for Draught animal power and Tractor operated farms according to the farm size. Data were collected from the stratified sample of 345 farmers from three purposively selected districts, Hexosa, Asasa and Sinana, where the agricultural mechanization operations are becoming increasingly practiced. The Tobit model showed that wheat farm land size, tractor use, and labor for the adoption of the chemical fertilizers, Sex of the household, land allocated for wheat land and tractor use for the adoption of improved seed, and Age of the households and total cultivated land for the adoption of agro chemicals were affect positively and significantly. Tractorization has positively and statistically significant affect the adoption of chemical fertilizers and improved seed rate, except the adoption of agro chemical application. Average of wheat production in all farms of tractor operated farms were higher (34.67 qt ha^{-1}) than other operated farms. There were the significance differences of wheat yield among different types of farms. There has been a reduction of total human labor employment to the extent of about 76 % on the tractor farms as compared to both the draught animal and mixed operated farms. The net income was higher on tractor-operated farms than both mixed and draught animal operated farms. Therefore, the tractor-operated farms were economically more efficient than the draught animal power and mixed operated farms especially in the case of farms of small and large farm sizes.*

KEYWORDS*:* tractorization, tobit model, economically, adoption, human labor employment.

INTRODUCTION

Even though she was among the first in the world to adopt the use of animal power in agricultural production, Ethiopia has remained unchanged with the centuries-old tillage tool known as the maresha, which is still used to till more than 95 percent of the land under cultivation for annual crops (Goe, 1987 and Ehret, 1997 sited in FAO, 2013a). When we see the world scenario of the agricultural mechanization pace specially for the Asian countries where it was very low before as that of Africa, it is under tremendous improvement in response to rising labour scarcity, greying agricultural populations, increasing labour costs and the increasing feminization of agriculture due

to the propensity of more men than women migrating to urban areas as well as to the development of modern value chains which respond to increasing market development and trade opportunities within the region and globally (FAO, 2015).

The farming system in most SSA countries is getting back to hand-hoe and to animal drawn implements. But the getting back to these traditional farming systems could not support the sustainable feeding of the population as the farm is highly facing problem of power both human and animal power due to different reasons like prevailing animal disease, shortage of feed, epidemic diseases like HIV. Recent research outputs shows that one of every three households in Ethiopia has no oxen while one of every three households has only one ox (Desalegn R., 2009). Moreover, the copping strategy for oxen shortage for those who had reported "No oxen" were "hand digging" for more than 2.2 million people which shows how much the problem was severe (CSA, 2009). Therefore, propositions of mechanizing could also be justified with the prevailing animal diseases, and shortage of feed, shortage of rural labor at the required quality and level at the required times. For instant, a survey conducted in Arsi zone on farming system characterization in 2016 evidenced that feed shortage was the number one ranked constraint in animal production while shortage of agricultural farm power was the third ranked crop production constraint (Tamrat, 2017).

Ethiopian has the lowest and poorest infrastructure development and also remains to have among the lowest mechanized agriculture in the region of East Africa (IGAD countries) according to FAO STAT, 2012 (FAO, 2013b). By 2003 Ethiopia was ranked 173rd out of 187 world countries having 2.71 tractors per 100 hectares of arable land where as it was 27.62, 16.27 and 9.04 in Kenya, Somalia and Uganda respectively while the largest number of tractor per 100 hectares of arable land was found in Iceland which was 15412.86 tractors with world average of 50tractors(http://www.nationmaster.com/country-info/stats/Agriculture/Agricultural machinery/Tractors-per-100-hectares-of-arable-land).

The use of tractor in developing countries was facing great challenges (arguments) from different development practitioners in two apparently different views. The two views are the substitution effect views and the net contribution views. The substitution views considered tractor and animals as two different power sources which are technically "perfect substitute of each other; i.e. any operation which could be performed by tractor can be performed by a combination of animal power, animal drawn implements and hand labor. This view considered the switch from animal power to tractor power to be guided by factor prices (or factor scarcities) (Binswanger. P., 1979). The second view is the "Net contributor" view of tractors. This group argues in extreme point that power is a primary constraint to agricultural production almost regardless of factor prices. According to them, tractor with its greater power allows more thorough or deeper tillage than with animal power. In addition, tractor attached implements also achieve a higher level of precession which also would lead to higher yields. Furthermore, tractor may be able to reclaim land which cannot be operated by animals at all. They also argue that the higher power and speed would allow more timely operations thus contributing to both higher yields and to a more extensive practice of double cropping. And higher yields and double cropping would lead to higher levels of output

which require more labor in operations not performed by the tractor.

Finally, they conclude their argument saying tractor could contribute to increased production without necessarily displacing labor and therefore tractorization would be consistent with employment objectives even in low-wage countries (G.W. Giles, 1969 and Roger Lawrence, 1970). However evidences from worldwide research outputs show that these two views are not much contradictory but some researchers were trying to explain their ideas forcefully like the case in India where net contributor view (S.S. Johl, 1973) and that of Ethiopia where substitution view (Kifle, 1972 and Holmberg, 1972) were presented.

When we see the present situation in Ethiopia, it seems that the view of substitution effect is accepted. This can be illustrated by the policy documents and it considered labor as abandoned and cheapest production factor in agriculture and gives more emphasis to labor intensity in agricultural production system. However, one can argue the importance of tractorization in Ethiopian agriculture from two points of views. The first one is the current feed shortage/price for draught animals and the other one is shortage of family labor because of sending children to school. The main objective of this study was to analyze economics of Tractorization in all directions like in adoption of other improved technologies, productivity at farm level, while the specific objectives of the study were: to analyze effect of tractorization on cropping intensity, crop yields and adoption of major agricultural inputs, to analyze the effect of tractorization on human labor employment, to determine the utilization and per unit cost of tractor power according to the farm size, to compare the different costs and profits for Draught animal power and Tractor operated farms according to the farm size groups.

RESEARCH METHODOLOGY

Description of the study areas

This research was undertaken in southeastern part of Oromia regional state especially in plateaus of Arsi, West Arsi and Bale zones. This part of the region is considered as the breadbasket the country where more than 75% of the bread wheat of the country is being produced (Hailu 1992). It has diversified agro-ecologies and production system. Mechanization has also long history in these areas starting from imperial regime when CADU and ARDU program were launched and the property owners were encouraged to mechanize their large farms and state farms. Arsi zone is divided into twenty-five administrative districts and one administrative town, which is Asella. It is situated between $6^0$45'N to $8^0$58'N latitude and $38^0$32'E to $40^0$50'E longitude (Atlas of Arsi zone, 2002). It has also surface area of about 20,737.24 km^2 (2,073,724 ha). The zone has four agro-climatic zones and altitude is the main source of difference. These diverse agro-climatic conditions and production system create wider opportunities of having long history for mechanization of agriculture.

West Arsi zone is also divided into eleven administrative districts and one administrative town Shashamane, which is the capital town of the zone. West-Arsi zone has land area of about 1,177,440 hectares or 12,938 km2. Crop-livestock mixed farming and pastoral and agro-

pastoralism are commonly practiced in all highlands, and mid and lowlands. According to data from zonal agricultural development office typical highlands of some districts like Asasa have more mechanized with the wheat production from the zone.Bale zone is the other south eastern part of Oromia regional state.it located between latitude of $5^0$22'-$8^0$08'N and longitude $38^0$41'-$40^0$44'E. Bale zone have eighteen administrative districts and two admistrative town which is Bale robe and Goba town. The zone has also diverse agro-climatic conditions for the production system, so it also crates good opportunities for mechanization purpose; especially Sinana woreda is more mechanized among the existing woreda of Bale zone.

Sampling Methods and Sample Size

Purposive sampling method and multi-stage sampling method were followed. The three zones Arsi, West Arsi and Bale zones were selected purposively because of their mechanization history. From each zones one district was selected. That means Hexosa from Arsi, Asasa from west Arsi and Sinana from Bale zone were selected purposively based on mechanization intensity and from both Hexosa and Asasa districts five kebeles from each were selected and four kebeles also from Sinana were selected purposively. The farmers were first stratified into three as large farmland holder, medium and small**. The cut-point was taken based on zonal/regional average of farm land from secondary data. That means less than 2 hectare for small farm, 2- 4 hectare for medium farm and those who have 4 and above hectares were large farm. Then the respondents at kebeles level were selected randomly from their strata. Totally fourteen villages were selected from three zones and total of three hundred forty five (345) respondents were interviewed.

Data Sources, types of data, and data collection methods

The data for study was collected from both primary and secondary sources. Cross-sectional data was collected from the survey of randomly selected sample farmers. The primary sources of data for this study were low level farmers (small farm), middle-level farmers, and large farmers on farm machineries and hiring the tractors. Primary cooperatives, unions and governmental agriculture and natural resource development offices from district to regional/federal ministry level were primary data sources for this study. These data were collected using structured and non-structured questionnaires and checklists through individual interviews and group discussion at each level. Secondary data was also collected from published and unpublished research outputs and governmental offices.

Methods of Data Analysis

Descriptive statistics like cross tabulation, mean, standard deviation, standard error, percentage were employed to summarize the socioeconomics characteristics of respondents, pair wise ranking were used to identify the challenges of using Tractor and oxen for land plowing. Analyses of variance (ANOVA) were also used in order to identify the statistically significant or not significant difference.

Cropping Intensity is Gross Cropped Area per Net Sown Area x 100.

$$CI = \frac{Gross\ cropped\ area}{Net\ Sown\ Area} * 100 \text{---------- (1)}$$

The intensity of cropping was calculated as the percentage ratios of cropped to total cultivated areas per farm while mean comparison were employed to compute effect of tractorization on yield of major crops (Wheat and Barley).To capture effect of tractor use on adoption of improved major agricultural inputs Tobit model were employed. The effect of tractorization on human labor employment data on plot size based inventory of labor were collected and mean were calculated for both tractors operated and draught animal operated farms as well as for mixed operated farms. To determine the utilization and per unit cost of tractor power according to the farm size groups and to compare the different costs and profits for draught animals/oxen and tractor operated farms according to the farm size, partial budgeting were used.

A partial budget analysis was carried out to determine the financial and economic profitability of different operating farm types. The budget technique was used to analyses cost revenue and profitability of operations carried out using oxen or tractors. The farm budgeting technique used was the Net profit (Net margin) model. Gross margin/Net margin technique was used to determine the profitability (costs and returns) of different operating farm types in the study area. The Net margin/Gross margin is the difference between Total Revenue (TR) and Total Variable Cost (TVC), that is,

$$GM = TR - TVC \text{---------- (2)}$$
$$NFI = GI - TC \text{---------- -- (3)}$$
$$TC = TVC + TFC \text{---------- (4)}$$

Where:

TR = Total revenue
TVC = Total variable cost
TFC = Total Fixed Cost
NFI = Net Farm Income

Gross Margin (GM)/Gross value of farm output = Total Revenue – Total Variable Cost (TVC).

The concept of costs and incomes implemented for this analysis were as follows:

Costs

(i) Cost A_1 includes value of hired human labor, value of hired and owned oxen/tractor labor, value of seed, value of fertilizers, value of pesticides, value of weedicides, and land revenue.
(ii) Cost A_2 includes cost A_1 plus rent paid for leased in land
(iii) Cost B is cost A_2 plus rental value of own land plus interest on owned fixed capital (excluding land)
(iv) Cost C is cost B plus imputed value of family labor.

Incomes

(i) Farm business income=Gross value of farm output-Cost A_1(cost A_2 in the case of tenant operated land)
(ii) Family labor income=Gross value of farm output -Cost B
(iii) Net income= Gross value of farm output –Cost C

Econometric Model

The econometric model was employed to analyze the data on effect of tractor use on the adoption of major agricultural inputs. There is broad class of model that has both discrete and continuous parts. One important model in this category is Tobit. Tobit is an extension of the probit model and it is really one approach to dealing with the problem of censored data. Some authors call such model limited dependent variable model because of the restriction put on the value taken by regressed (Gujarati, 2003). Selection of econometric model requires taking into account the nature of the dependent variable, among others. A dependent variable which bears a zero value for a significant portion of the observations requires a censored regression model (Two-limit Tobit model). Such censored regression is preferred because it uses data at the limit as well as those above the limit to estimate regression.

Following Maddala (1992) and Johnston and Dinardo (1997) Green (2000) and (Gujarati, 2003). The equation for the model is constructed as:

$Y^*=\beta_0+\beta_i x_i+U_i$

$Y=Y^*$ if $\beta_0+\beta_i x_i+U_i > 0$---------- (5)

$Yi=0$if $\beta_0+\beta_i x_i+U_i < 0$

Where,

Yi= the observed dependent variable

Y*= latent variable (which is not observable)

Xi = Vector of explanatory variable

β = vector of parameters to be estimated

Ui = an independent normally distributed error term with zero mean and constant variance

The model parameters are estimated by maximizing the Tobit likelihood function of the following form [Maddala (1997)].

$$L = \Pi \ \frac{1}{\alpha} f\left(\frac{Yi-\beta i\times i}{\alpha}\right) \Pi \ \ F\left(\frac{-\beta i\times i}{\alpha}\right) \text{---------- (6)}$$

Where f and F are respectively, the density function and cumulative distribution function of Yi*, Π yi*>0 means the product over those i for which yi*>0, and Π yi* ≤0 means the product over those i for which yi* ≤ 0.

The explanation of Tobit model coefficients is the same with that of uncensored linear model coefficients. The significant variables do not all have the same impact on the adoption of major agricultural inputs. Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the explanatory variables.

That is probability of the adoption of major agricultural inputs. As cited in "[Maddala (1992) and 1997)]" proposed the following techniques to decompose the effects of explanatory variables into adoption effects.

Thus; change in Xi (explanatory variables) has two effects. It affects the conditional mean of Yi in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. Similarly, in this study, the marginal effect of explanatory variables will be estimated as follows.

The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial \mathrm{E(Yi)}}{\partial(\times i)} = F(z)\beta i \text{---------- (7)}$$

Where, $\frac{\beta i \times i}{\alpha}$ is donated by Z,

The Change in the probability of adopting a technology as independent variable Xi change is:

$\frac{\partial \mathrm{F(z)}}{\partial(\times i)} = f(z)\frac{\beta i}{\alpha}$ ---------- (8)

Where,

F (z) is the cumulative normal distribution of Z, f (z) is the value of the derivative of the normal curve at a given point (i.e., unit normal density), Z is the z-score for the area under normal curve, is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Dependent variables:

Three dependent variables are going to be estimated by the selected model. The dependent variable in the Tobit model analysis has been the amount of chemical fertilizers, improved seed rate and Agro chemicals (Herbicides, Weedicides and Pesticides) applied and are described as follows;

Chemical fertilizers: it is the amount of fertilizers including (Dap, Urea and NPS) that respondents are using per a hectare of land and continuous variable measured in terms of kilogram. It will be estimated by linear regression model by using maximum likelihood estimates procedure by Tobit model.

Improved seed rate: it is the amount of improved seed that farmers are using per a hectare of land and continuous variable measured in terms of quintals. It will be estimated by linear regression model by using maximum likelihood estimates procedure by Tobit model.

Agro chemical application: it is the amount of different agro chemical application that means herbicides, weedicides and pesticides that farmers are use per hectare of land and continuous variable measured in terms of litter.

Independent variables in the model are defined as follows:

SEXHH= Sex of the household head (1=male, 0= otherwise)
AGEHH = Represents the age of the household head (in years).
EDUCTHH = the level of formal education of the household (year of schooling).
CULTLND = Continuous, the total cultivated land of household measured in hectare
EXPWHFM= Continuous variable, wheat experience household farm experience in year
LNSWHT= Continuous variable, the total wheat farm size of the household in hectare.
FMLYSIZE = Discrete, the total number of family in the household (in number)
TLU= Continuous, Livestock holding computed using the TLU using a conversion factors.
TRCTRUSE= Dummy, access to tractor, (1 if the household has use to tractor and 0 otherwise)
PLTSIZE= Number of plots owned and cultivated by household.
EXTCNT= Categorical variable, the frequency of extension contact which takes value, 0, 1,2,3,4

and 5, If no contact, every day every week, every fortnight, and every month respectively.
DSTHMD= Continuous variable, the distance of household from development agent (km)
MEMCOOP= Dummy, cooperative members (1 if the household is the member, 0 otherwise)
DSTMRK= Continuous, the distance home from Market, measured in (km)
LABOR = Hired labor on farm (man equivalent)

RESULTS AND DISCUSSION

This section presents the results of the analyses of the cross-sectional survey data of the study. Descriptive statistics on socio-economic profile of households and econometric estimation results of the analyses of effect of tractor utilization comparing with draught animals power for operating the farm practice have been given under their respective sections. Results are presented based on their districts or Zones i.e. Hexosa (Arsi), Asasa (West Arsi), and Sinana (Bale) zones.

Table 1. Number of respondents in each selected districts.

Name of districts	N	Percent	Cumulative percent
Hexosa	139	40.29	40.29
Asasa	130	37.68	77.97
Sinana	76	22.03	100.00
Total	345	100.00	

According to our sample survey were indicate out of total sample households around 139 respondents from Hexosa district and about 130 and 76 respondents from Asasa and Sinana respectively (Table 1). That means about 40 % were from Hexosa and 38% and 22 % were from Asasa and Sinana districts respectively.

The Socioeconomic Characteristics of Different Types of Farm Utilization.
Socioeconomic characteristics of the household analyses of different type of farm operation utilization according to Age of the households, Education level of households, Marital status, Family size, Farm size (Total cultivated land area), and years of farm experience (wheat experience), Total cultivated wheat land area, total production of wheat (yield per plot and total output), family labor, number of plots, number of oxen Owned by households and number of TLU of the households.

Table 2. The socio-economic characteristics of different type of farm utilization in study area.

	DAP (N=69)		Mixed (N=268)		Tractor (N=8)			
Variables	Mean	Std.Error	Mean	Std.Error	Mean	Std.Error	F	Sig.
Age	47.12	1.20	44.05	.80	47.37	4.76	1.941	.145
Education	4.61	.397	5.95	.211	5.25		1.13	4.290** .014
Family size	8.24	.395	7.07	.173	8.62	1.37	5.055**	.007
Land wheat	1.42	.099	2.22	.098	2.44	.57	8.28***	.628
Cultivatedlnd	1.92	.116	2.52	.010	2.67	.569	4.11**	.017
Experience	24.4	1.60	23.8	.820	27	4.61	.323	.724
Yield/plot	35.63	2.47	62.42	2.96	49.75	4.78	10.34***	.000

Output		35.50	3.06		76.07	3.85		84.87		22.13
13.97*** .000										
Labor	29.43	2.11		37.58	1.48		9.62		0.73	8.621*** .000
Oxen	22.01	1.59		19.39	.67		0.00		.00	13.41*** .000
TLU	5.90	.560		5.57	.234		9.98		1.78	4.686** .010
Plot	2.31	.148		2.36	.092		2		.188	2.66 .766

Source: Computed from own survey.
*** Significant at 5 percent level. *** Significant at 1 percent level.*

Household head	DAP only	Mixed	Tractor only used
Male headed	68	250	7
Female headed	1	18	1
Total household head	69	268	8

Variables	**N**	**Percent**	**Cumulative percent**
Male headed	325	94.20	94.20
Female headed	20	5.80	100
Married	333	96.52	96.52
Single	6	1.74	98.26
Widowed	3	0.87	99.13
Divorced	3	0.87	100

Source: Computed from own survey data, 2019/20

Results in Table 2 shows that the mean household head Age was 47, 44 and 47 years and educational background was about 4, 6, 5 years of education for the only DAP used, mixed farm and only tractor used respectively. Hence, education is hypothesized to increase the probability that household farmers will use technologies or tractor utilization. The overall mean family size of the sample household was around 8, 7, 8 for the respective type of farms per household with total female family and male family per household of 3.95 and 4.01 for only DAP used household. The average wheat farm experience of the respondents was around 24, 23.8 and 27 years for only dap, mixed and only tractor used respectively with maximum experience of 65 years and minimum of zero.

Land is the utmost important resource in farming professional and the average total cultivated land of the households was around 2, 2.5 and 2.7 hectares for respective types of farms, while the minimum land allocated for wheat production purpose was 0.25, 0.2 and 0.42 hectares, and the maximum size of land was 4, 12 and 6 hectares for draught animals power only, mixed and only tractor respectively. The mean values for land allocated for wheat productions were 1.4 hectare for only draught animal power used, 2.2 hectare for mixed operated farms and 2.4 hectare for tractor only used farms. The average total production of wheat was about 35.5, 76 and 84.8 kg for the DAP only, mixed and tractor only operated farms respectively.Out of 345 sampled households only 20 (5.8%) were female headed while the rest 325 (94%) were male. And majority of the household head were married.

Households Status of the Respondents

Table 3. The households' status of respondents according to farm type

HH status	N	Percent	Cumulative percent
Model	62	17.97	17.97
Middle	254	73.62	91.59
Resource poor	29	8.41	100.00

	Types of farm		
HH status	DAP farm	Mixed farm	Tractor farm
Model	9	50	3
Middle level	48	201	5
Resource poor	12	17	

Resource Ownership of the Respondents

The households are generally classified in to three as model, middle level and resource poor farmers in terms of their resource ownership according to office of agriculture and natural resource development. Accordingly, around 18 percent of the households are classified as model farmer, while the rest 73.6% and 8.4% were classified as middle level and resource-poor respectively. According to our results economically poor households does not use tractor, the only use tractor were model and middle level households.

Wheat Farm Information:

Table 4. Wheat farm information

Variables	N	Mean	Std. Dev.	Min	Max
Own wheat farm	345	1.422188	1.062507	0	8
Wheat farm rented in	345	.5392754	1.129153	0	10
Wheat farm shared in	345	.1127536	.3650776	0	2.5
No of wheat farm plots	345	2.347826	1.440951	1	9

The average own wheat farm of the respondents was around 1.42 hectares while the average of wheat farm rented in and shared in was 0.53 and 0.11 hectares respectively. The average number of wheat farm plots of the respondents was around 2.34 with maximum 9 numbers of plots and 1 minimum number of plots of the respondents.

Tractor Utilization in sample districts and percentages.

Table 5 Tractor Utilization in sample household districts

Sample districts	How often do you use tractor					Total
	Every year	Every two years	Sometimes	Rarely	Never	
Hexosa	126 (90.6)	4 (2.9)	3 (2.2)	0	6 (4.3)	139
Asasa	64 (49.2)	10 (7.7)	13 (10)	4 (3.1)	39 (30)	130
Sinana	37 (48.7)	33 (43.4)	1 (1.3)	0	5 (6.6)	76
Total	227 (65.8)	47 (13.6)	17 (4.9)	4 (1.2)	50 (14.5)	345(100)

Sample districts	Using tractor year after year		Total	Percentages
	No	Yes		
Hexosa	6	133	139	40.28
Asasa	39	91	130	37.68
Sinana	5	71	76	22.02
Total	50 (14.5)	295 (85.5)	345	100

***Note:** The figures in parentheses indicated that the percentage of Tractor utilization within the sample districts.*

The overall result shows that around 66% were used tractor every year, while 13.6%, 5%, 1.2% and 14.5% were use tractor every two years, sometimes, rarely and never respectively.
Hexosa district about 90.6% were used tractor every year, while about 4 % were never use tractor .and in Asasa district about 49.2% were used tractor every year while about 30% were never use tractor according to our survey result. And in Sinana district about 48.7% were used tractor from year to year while about 6.6% were never use tractor according to our sample households.
When we compare the districts with each other's Hexosa district were take the highest percentage from among the districts that means about 90.6% were use tractor every year, while around 30% from Asasa district were never use tractor. This indicated that around 85.5 percent were used tractor every year, only 14.5 percent was not used tractor every year.

Land preparation in Sample Districts by Different Types of Farms.
Table 6 Land preparation by different types of farms

Land preparation	Times of plowing	Frequency	Percent
Using only tractor	1	140	40.6
Using only draught animals	4	148	42.9
Plowing by draught animal after land prepared by tractor	3	128	37.1

Land preparation was operated once time by only tractor followed by draught animals three times before sowing. Out of the total sample around 140 farmers were using only tractor for land preparation only once time. This indicated that most of the time tractor used only for primary tillage or for land preparation, but around 148 farmers/respondents were used only by using draught animals four times for their land preparation before planting according to the findings. That means around 43 percent of the farmers were using only draught animals for their operating the farm following by using only tractor about 40.6 percent.

Households in different Farm size groups in hectare and their percentages
Table 7. Sample Households in different Farm size groups in hectare.

Sample districts	Farm size groups			Total
	up to 2 (Small)	2 – 4 (Medium)	4 and above (Large)	

Hexosa	61 (43.9)	61 (43.9)	17 (12.2)	139
Asasa	59 (45.4)	61 (46.9)	10 (7.7)	130
Sinana	24 (31.6)	33 (43.4)	19 (25.0)	76
Total	144 (41.7)	155 (44.9)	46 (13.3)	345

Farm size groups	Frequency	Percent	Valid Percent	Cumulative Percent
Small farms	144	41.7	41.7	41.7
Medium farms	155	44.9	44.9	86.7
Large farms	46	13.3	13.3	100.0
Total	345	100.0	100.0	

Table 7 shows that in all sample districts, larger proportion of households own land holding size ranging from 2 to 4 hectares. The household percentage in Hexosa, Asasa, and Sinana districts in this land holding class was about 44, 47 and 43 percent's, respectively. The highest percentage of households (40.3 percent) was found in Hexosa district, and the smallest percentage of households (22 %) was found in Sinana district. Out of total sampled households only 46 (13%) were categorized in large farms, while around 144 (42%) and 145 (45%) respondents were small and medium farms.

Table 8. The percentages of different type of Farms in the study areas.

Types of Farm	Frequency	Percent	Valid Percent	Cumulative Percent
Only DAP used	69	20.0	20.0	20.0
Mixed used	268	77.7	77.7	97.7
Only Tractor used	8	2.3	2.3	100.0
Total	345	100.0	100.0	

According to the above table mixed farm or tractor and draught animals' farm operated has been the largest percentage, which means around 78 percent. While the percentage of only draught animals used and the only tractors used percent were 20 and only 2 percent respectively according to their order.

Classification of Farm size groups according to different types of Farms.

Table 9. Classification of Farm size groups according to different types of Farms (only draught animals, mixed and only tractor used farm)

Farm size groups	Type of Farms			Total
	Only DAP used	Tractor +DAP used (Mixed)	Only Tractor used	
Small farm	39	104	1	144
Medium farm	27	122	6	155

Large farm	3	42	1	46
All farms	69	268	8	345

From total sample size about 69 respondents were only using DAP (draught animal power) for operating their land, according to farm size groups up to 2ha (small farm), 2-4ha (medium farm) and above 4ha (large farm) was about 39, 27 and 3 respondents respectively. 268 and only 8 respondents were using mixed farm (using tractor and draught animals) and only tractor use. In mixed (Tractor +draught animal operated) farm about 104,122 and 42 respondents from small, medium and large farm respectively. In only tractor operated farm maximum respondents were from medium farm size group, which means about 6 respondents out of total of 8 respondents.

Table 10 Total cultivated land and land size for wheat production according to sample districts and farm size groups.

Sample districts	Total cultivated crop land	Land size for wheat
Hexosa	337.15	313.48
Asasa	282.55	227.38
Sinana	209.26	172.50
Grand Total	828.96	713.36
Farm size groups	**Total cultivated crop land**	**Land size for wheat**
Small farm	174.75	138.95
Medium farm	407.78	347.61
Large farm	246.43	226.8
All farms	828.96	713.36

Source: Computed from own survey

Total cultivated crop land of the sample districts was around 828.96 hectares out of that about 713.36 hectares were allocated for the production of wheat according to our sample. From the total cultivated crop land the largest proportion of land from Hexosa district followed by Asasa and Sinana. The same as to the land size for wheat production, Hexosa was the large proportion among the districts that means about 313.48 hectares out of total wheat land of 713.36 hectares, about half of total land for wheat production. According to the farm size group the largest proportion of total cultivated land was in medium farms followed by large farms and small farms and the same as for the land for wheat cultivated land.

The Percentage Distribution of Wheat Cropped Area According to Farm Types.

The total cultivated area, wheat area as percent of total cultivated area for the three types of farm. That means for DAP (only draught animal power), for mixed farm (Draught animal power and tractor) and for the only tractor operated farms are presented in table below.

Table 11 Distribution of wheat cropped area in the sample area.

Size-groups	T. farm	T. cultivated area	Land for wheat	Wheat area as percentage of total cultivated land
Small farm	DAP	49.82	34.85	69.95
	Mixed	124.51	103.68	83.27
	Tractor	.42	.42	100.00
Medium farm	DAP	69.63	51.75	74.32
	Mixed	323.24	282.7	87.45
	Tractor	14.91	13.16	88.26
Large farm	DAP	13.43	11.05	82.27
	Mixed	227.00	209.75	92.40
	Tractor	6.00	6.00	100.00
All farms	DAP	132.88	97.65	73.48
	Mixed	674.75	596.13	88.34
	Tractor	21.33	19.58	91.79

NB. DAP refers to Draught animal power operated farm

T+ DAP (Mixed farm) refers to both Tractor and Draught animal power operated farms.
According to local and zonal office of agriculture and natural resource development, the farmers or households are generally classified as small, medium and large farmers in terms of their farm land size. So depending on this we were classified the farmers as below 2 hectares is small, 2-4 hectares is medium, and 4 hectares and above is large farmers. It can be perceived from the table that on an average, the percentage area wheat land was 73.48, 88.34 and 91.79 percent for draught animal power only, mixed and for only Tractor operated farms respectively. The result also shows that the percentage area of wheat land of only tractor operated farms were higher than that of other operated farms in all farm size groups followed by mixed operated farms. There was the significance difference in the proportions of the wheat area on the tractor operated farms in all farm size groups.

Effect of Tractorization on Cropping Intensity, Major Crop Yields and Adoption of Major Agricultural Inputs.

Effect of Tractorization on Cropping Intensity.
Farming mechanization has made substantial influence in improving cropping intensity. Cropping Intensity is the ratio of Net Area Sown to the Total Cropped Area. The cultivated area per farm, cropped area and intensity of cropping for only draught animal, mixed and only tractor operated farms in the sample are shown in table below. The study revealed that only tractor operated farms had a higher cropping intensity of 91.6 per cent as followed by 86.8 percent in the case of mixed operated farms and 73.7 of only draught animals operated farms.

The cropping intensity of only tractor operated farms was significantly higher in comparison with the cropping intensity of all farms and only draught animals operated farms. The cropping intensity in mixed operated farms was also significantly higher in comparison with the only draught animals

operated farms. The intensity of cropping had a relationship with the mechanization technologies and it has positive relationship with tractorization. There was the significance difference of cropping intensity at 1 per cent among the types of operated farms.

Table 12. Types of Farm and Intensity of Cropping on Different Categories on Farms

All farms Intensity of Groups cropping (%)	Cultivated area Per farm	Cropped area per farm
DAP 73.48	132.88	97.65
Mixed 88.34	674.75	596.13
Tractor 91.79	21.33	19.58

Variables	N	Mean	Std.Error	F	Sig.
DAP only	69	.7371	.02373	17.753***	.000
Mixed	268	.8680	.00972		
Tractor only	8	.9164	.03735		
All farms	345	.8429	.00939		

Source: Computed from own survey
**** Significant at 1 per cent level.*

Effect of Tractorization on Yield Rate of Major Crops.
The average yields per hectare of major important crops on the only using draught animal power, mixed operated farms and only Tractor operated holdings according to the farm size are presented in table 13 below. The overall average crop yields per hectare were found to be higher on the tractor farms as compared to that on the draught animal operated farms.

Table 13. Yield production of major crops according to farm size groups and type of farms.

Farm size Groups	Wheat production (qt/farm) DAP	Mixed	Tractor	Barley production (qt/farm) DAP	Mixed	Tractor
Small farms ……	1027.00	3836.00	16.00	147.00	205.00	.00
Medium farms ……	1231.00	9189.00	463.00	203.00	680.50	36.00
Large farms ……..	192.00	7364.00	200.00	40.00	341.00	.00
All farms ……..	2450.00	20389.00	679.00	390.00	1226.50	36.00

Source: Computed from own survey data.

Table 14 Classification of farm size group according to total cultivated land of major crops

Farm size groups	Total cultivated area(ha)			Land for wheat(ha)			Land for barley(ha)		
		DAP	**Mixed**	**T**		**DAP**	**Mixed**	**T**		**DAP**	**Mixed**	**T**
Small farms	49.82	124.51	0.42	34.85	103.68	.42	7.00	9.48	0.00
Medium farms	69.63	323.24	14.91	51.75	282.7	13.16	12.10	31.70	1.75
Large farms	13.43	227.00	6.00	11.05	209.75	6.00	1.75	17.25	0.00
All farms	132.88	674.75	21.33	97.65	596.13	19.58	20.85	58.43	1.75

This section provides area, production and yield of major crops of the study area according to the different operated farms. The major agricultural crops produced in the study areas were wheat and barley. The average agricultural land allotted to wheat was 97.65, 596.13, and 19.58 hectares respectively according to their farm type in all farm groups (Table 14.) and total production of wheat was 2450, 20389 and 679 quintals per farms size in all farms. Barley is the second dominant crop with average production of 390, 1226.5 and 36 per farm in all farms and in their respective operated farms. The average land allocated for barley was 20.85, 58.43 and 1.75 hectares in all farms for only draught animal, mixed and only tractor operated farms respectively.

Table 15. The average yield of wheat and barley production according to their farm size.

	Yield of Wheat			Yield of Barley		
Farm size	**DAP**	**Mixed**	**Tractor**	**DAP**	**Mixed**	**Tractor**
Small farms ……	29.46	36.99	38.09	21.00	21.62	.00
Medium Farms……	23.78	32.50	35.18	16.77	21.46	20.57
Large farms ……..	17.37	35.10	33.33	22.85	19.76	.00
All farms ……..	25.08	34.20	34.67	18.70	20.99	20.57

According to the result, average yield of wheat was the highest (38.09 qt ha^{-1}) in small farm by only tractor operated farms. But the highest yield of barley was 22.85 qt ha^{-1} in large farm of only draught animal power operated farm. It was found that the yields on the tractor farms were significantly higher than the draught animals and Mixed operated farms on both small and medium farm size and in all farms, except on the large farm size for wheat production, and the yield on the mixed operated farms were significantly higher than the yield of draught animals and only tractor operated farms for barley production in small and medium farms and in all farms, except in large farm of draught animal power. Generally, the yield of wheat crops was relatively better when it was operated by tractor and barley was also better by mixed operated farms. That means the average of wheat production in all farms of tractor operated farms were higher (34.67 qt ha^{-1}) than other operated farms. Higher yields on tractor operated farms may be recognized to sufficient tillage operations, timely sowing, precision in depth of planting and plant population control which are made possible due to the use of tractors. There were the significance differences of wheat yield among different types of farms.

Table 15. The average yield of wheat and barley production according to their type of farms.

Variables	Type of farms	N	Mean	Std.Error	F	Sig.
Yield of Wheat	DAP only	69	27.85	1.94	7.345***	.001
	Mixed	268	35.67	.91		
	Tractor only	8	35.01	4.24		
	All farms	345	34.09	.83		
Yield of Barley	DAP only	44	20.02	1.67	.270	.764
	Mixed	102	21.18	.78		
	Tractor only	4	20.16	3.65		
	All farms	150	20.81	.72		

Source: Computed from own survey data *** *Significant at 1 per cent level.*

Effect of Tractor use on Adoption of Improved Major Agricultural Inputs.

Table 16. The mean of major agricultural inputs according to type of farms.

	DAP only		Mixed		Tractor only			
Variables	Mean	Std.Error	Mean	Std.Error	Mean	SD	F	Sig.
Seed kg/ha	204.71	6.43	226.86	3.80	162.5	32.38	7.273***	.001
Dap kg/ha	98.91	4.79	128.73	3.61	112.5	29.5	7.749***	.001
Urea kg/ha	67.39	6.02	76.58	3.78	75	13.36	.658	.518
NPS kg/ha	5.07	3.28	12.12	2.67	18.75	18.75	.949	.388
Herbicides (lit/ha)	1.38	0.098	1.34	.045	1.06	.113	.684	.505
Pesticides (lit /ha)	1.54	0 .92	1.52	.05	1.12	.12	.976	.378

Source: Computed from own survey, 2019/20 *** *Significant at 1 per cent level.*

According to our results indicates seeding rate per hectare of Tractor operated farms were more recommended as compared to using only draught animal power and mixed operated farms. That means 162.5 kg ha^{-1} for tractor operated use, 226.86 kg ha^{-1} for mixed operated farm and 204.7 kg ha^{-1} for only draught animals operated farms. There was significance difference of seeding rate per hectare of tractor use and other operated farms. And no significance difference of urea kg per

hectare, herbicides litter per hectare and pesticides litter per hectare among the operated farms, but there were significance difference of fertilizer (Dap) used kg per hectare at 1 percent.
The survey result also showed that about 111 (32%) of the respondents had access to using improved seed regularly or year after year , among those who had access improved seed every years 26% of them uses tractor services while about 33 % of them uses mixed farms.

Maximum Likelihood Estimates for the Tobit model for Major Agricultural Inputs
An econometric (Tobit) model was used to determine the influence of various personal, demographic, socio-economic, institutional and psychological variables on adoption of major agricultural inputs (chemical fertilizers, improved seed and agro chemicals). The estimations of parameters of the variables expected to influence adoption of major agricultural inputs are presented on the respective section. Fifteen explanatory variables of which some are dummy and some variables are continuous were taken to the model for analysis.

Effect of Tractorization on Adoption of Chemical fertilizers
The results of the Tobit model presented in Table below gives the maximum likelihood parameter estimates of the amount of chemical fertilizers applied.
Table 17 Maximum Likelihood Estimates for the Tobit model for Chemical fertilizers

		Number of obs = 345		Uncensored=344	
Log likelihood = -2612.8902		LR chi2 (15) = 81.98		Left-censored = 0	
		Prob > chi2 = 0.0000		Right –censored=1	
		Pseudo R2 = 0.0154		Predicted prob= 464.88	
Variables	Coef.	Std. Err.	t	P>|t|	dy/dx
SEXHH	-84.87108	114.8401	-0.74	0.460	-84.87108
AGEHH	-2.941143	2.088169	-1.41	0.160	-2.941143
EDUCTHH	-7.739695	8.555121	-0.90	0.366	-7.739695
CULTLND	-30.75621	72.15211	-0.43	0.670	-30.75621
EXPWHFM	-1.065261	2.171407	-0.49	0.624	-1.065261
LNSWHT	169.6896	85.37943	1.99*	0.048	169.6896
FMLYSIZE	9.890271	9.043921	1.09	0.275	9.890271
TLU	8.265481	6.427866	1.29	0.199	8.265481
TRCTRUSE	158.8076	65.47281	2.43**	0.016	158.8076
PLTSIZE	-79.39884	50.73892	-1.56	0.119	-79.39884
EXTCNT	-49.73676	20.61771	-2.41**	0.016	-49.73676
DSTHMD	-53.69446	61.01011	-0.88	0.379	-53.69446
MEMCOOP	-125.6405	59.65713	-2.11*	0.036	-125.6405
DSTMRK	-2.178769	7.862229	-0.28	0.782	-2.178769
LABOR	5.80568	1.240842	4.68***	0.000	5.80568
Cons	359.0336	217.0061	1.65	0.099	

Note: ****, ** and * indicate the level of Significance at 1, 5 and 10 percent, respectively.*

The results show that wheat farm land size (LNSWHT) had statistically significant and positively influences at 10 percent level on adoption of use of fertilizer, which means that an increase in

wheat farm land size by 1 ha increases the probability of using the fertilizer by 169.7 percent; This implies that farmers with larger wheat farm land size adopt more fertilizer as expected since they are likely to have more opportunities to learn about new technology, have more incentive to adopt it, and are able to bear risks associated with early technology adoption (Feder et al, 1985; Feder and Slade, 1984).

Tractor user (TRCTRUSE) found to be positive and significant influence on the likelihood of adoption of using fertilizer at 5 percent significance level. The results computed indicated that increase having access to tractor by 1 percent increases the probability of adoption of fertilizer by 158.8 percent.Having extension contact (EXTCNT) has been negative and statistically significant variable in determining adoption of fertilizer at 5 percent significance level, which implies a decrease in contact with extension agent decreases probability of adoption of fertilizer by 49.7 percent. This is due to the fact that, frequency of contacts with extension agents decreases the probability of acquiring up-to-date information on the new agricultural technologies.

Members of cooperatives (MEMCOOP) has been negative and statistically significant variable in determining adoption of fertilizer at 10 percent significance level, which implies a decrease in members of cooperatives decreases probability of adoption of fertilizer by 125.6 percent. Labor (man equivalent) has been found to be a significant variable affecting the amount of fertilizer adopted positively at 1 percent significance level. That means an increase in labor by one person increases the probability of using the fertilizer by 5.8 percent. Households with larger labors are expected to apply more fertilizer in order to produce more food for the family. On the other hand larger labor minimizes the shortage of labour and thereby enabling the household to purchase and use more fertilizer. Generally, the Tobit model results of this study revealed that a unit increase in explanatory variable will bring certain percent of change or increases on the probability of adopt the fertilizers.

Effect of Tractorization on Adoption of Improved Seed

Table 18: Maximum Likelihood Estimates for the Tobit model for determinants of adoption of improved seed

Log likelihood = -1845.4432	Number of obs = 345	Uncensored = 330	
	LR chi2 (15) = 51.01	Left-censored = 2	
	Prob > chi2 = 0.0000	Right-censored = 13	
	Pseudo R2 = 0.0136	Predicted prob= 221.59	

Variables	Coef.	Std. Err.	t	P>|t|	dy/dx
SEXHH	27.1097	14.58416	1.86*	0.064	27.1097
AGEHH	-.1919205	.2642193	-0.73	0.468	-.1919205
EDUCTHH	-1.634453	1.083293	-1.51	0.132	-1.634453
CULTLND	-20.96605	9.134526	-2.30**	0.022	-20.96605
EXPWHFM	.1836468	.2749551	0.67	0.505	.1836468
LNSWHT	19.91231	10.81307	1.84*	0.066	19.91231
FMLYSIZE	-.5017704	1.144099	-0.44	0.661	-.5017704
TLU	1.085295	.8150211	1.33	0.184	1.085295

TRCTRUSE	24.17947	8.280803	2.92***	0.004	24.17947
PLTSIZE	-1.262442	6.429975	-0.20	0.844	-1.262442
EXTCNT	-9.574115	2.609235	-3.67***	0.000	-9.574115
DSTHMD	3.169887	7.727374	0.41	0.682	3.169887
MEMCOOP	4.827703	7.556086	0.64	0.523	4.827703
DSTMRK	-.6207059	.9949783	-0.62	0.533	-.6207059
LABOR	.2041717	.1568629	1.30	0.194	.2041717
Constant	201.2855	27.51086	7.32***	0.000	

Source: Computed from own survey.

Note: ****, and * indicate the level of Significance at 1, and 10 percent, respectively.*

The Tobit model result show that sex of household head, land allocated for wheat, and tractor use have positive and significant relationship with improved seed adoption decision while total cultivated land of household and contact with extension agents carried a negative sign indicating their negative relation with improved seed rate adoption decision.

Implication of Sex (gender) of household head on improved seed rate adoption is positive and statistically significant at 10 percent level. Male-headed households, citrus paribus, have 27.1% higher probability of participation than female-headed households. In fact, in the study districts, authorizing females to be a household head is not yet well developed and recognized.

The results also show that total cultivated land or land holding size of the household head (CULTLND) had statistically significant and negatively influences at 5 percent level on adoption of improved seed rate, which means that a decrease in total cultivated farm land size by 1 ha decreases the probability of adoption of improved seed rate by 20.9 percent; This implies that farmers with larger cultivated farm land size adopt more improved seed rate.

Wheat farm land size (LNSWHT) had statistically significant and positively influences at 10 percent level on adoption of improved seed rate, which means that an increase in wheat farm land size by 1 ha increase the probability of adoption of improved seed rate by 19.9 percent; This implies that farmers with larger wheat farm land size adopt more using improved seed rate.Tractor user (TRCTRUSE) found to be positive and significant influence on the likelihood of adoption of improved seed rate at 1 percent significance level. The results computed indicated that increase having access to tractor use by 1 percent increases the probability of adoption of improved seed rate by 24.1 percent. The model result reveals that contact with extension workers (EXTCNT) negatively affects adoption of improved seed rate and statistically significant at 1 percent level of significance. The magnitude of negative sign show that, farmers who are not visited by extension agents, keeping other things constant, have 9.5 percent lower probability of adopting improved seed rate unlike non-contacted farmers with extension agents.

3.6.4.3 Effect of Tractorization on Adoption of Agro chemicals application

Table 19 Maximum Likelihood Estimates for the Tobit model for Agro chemicals (weedicide, herbicide and pesticide) application.

	Number of obs = 345	Uncensored= 68

Log likelihood = -269.18102		LR chi2 (15) = 89.30		Left-censored = 276	
		Prob > chi2 = 0.0000		Right –censored=1	
		Pseudo R2 = 0.1423		Predicted prob= -4.54	
Variables	Coef.	Std. Err.	t	P>|t|	dy/dx
SEXHH	-2.039579	1.8284	-1.12	0.265	-2.039579
AGEHH	.0557032	.0280372	1.99*	0.048	.0557032
EDUCTHH	-.1840454	.1118173	-1.65	0.101	-.1840454
CULTLND	3.829187	.913932	4.19***	0.000	3.829187
EXPWHFM	.0258629	.0285497	0.91	0.366	.0258629
LNSWHT	-3.720941	1.1026	-3.37***	0.001	-3.720941
FMLYSIZE	.0769607	.1070101	0.72	0.473	.0769607
TLU	-.004308	.077564	-0.06	0.956	-.004308
TRCTRUSE	-1.988194	.7589478	-2.62*	0.009	-1.988194
PLTSIZE	-2.392733	.7888869	-3.03***	0.003	-2.392733
EXTCNT	.13489	2643807	0.51	0.610	.13489
DSTHMD	1.120337	.691249	1.62	0.106	1.120337
MEMCOOP	-1.024248	.7222722	-1.42	0.157	-1.024248
DSTMRK	.0962727	.0949767	1.01	0.311	.0962727
LABOR	.0063166	.0196432	0.32	0.748	.0063166
Constant	-1.24867	2.955804	-0.42	0.673	

Source: Computed from own survey.

Note: ****, and * indicate the level of Significance at 1, and 10 percent, respectively.*

The result of the model showed that the Age of the household head had significant at 10 percent level with positive relationship. A year increase in the age of the respondent increases probability of adoption of using chemical application by 0.05 percent. This implies that the older the respondent, the higher the probability of adoption of different chemicals.

The results also show that total cultivated land or land holding size of the household head (CULTLND) had statistically significant and positively influences at 1 percent level on adoption of different chemical application, which means that an increase in cultivated farm land size by 1 ha increases the probability of using the chemical application by 3.8 percent; This implies that farmers with larger cultivated farm land size adopt more agro chemical application.

Wheat farm land size (LNSWHT) had statistically significant and negatively influences at 1 percent level on adoption of agro chemical application, which means that a decrease in wheat farm land size by 1 ha decrease the probability of using the agro chemical application by 3.7 percent; This implies that farmers with lower wheat farm land size adopt less using agro chemicals application.

Tractor user (TRCTRUSE) had negative and significant influence on the adoption of using agro chemical application at 10 percent significance level. The results computed indicated that decrease having access to tractor by 1 percent decreases the probability of adoption of agro chemicals application by 1.9 percent.

Number of Plot farm size of farmer's holds was another variable that determine the adoption of

agro chemical application. Number of farm plots (PLTSIZE) has been negatively and significant influence on the adoption of different agro chemical application at 1 percent significance level. This implies that, number of farm plot is a measure of farm disintegration and those farmers who have less number of farm plots have less interested to adopt different agro chemical application.

Effect of Tractorization on Human Labor Employment.

Table 20. Utilization of Human Labor per Farm hectare in selected districts

	DAP only			Mixed			Tractor only		
Farm size groups	**MD**	**OD**	**TL**	**MD**	**OD**	**TL**	**MD**	**HL**	**TL**
Small farms	34.66	19.43	54.09	30.94	16.88	47.82	8	8	16 (65.5)
Medium farms	42.51	25.66	68.17	36.95	18.73	55.68	9.83	3	12.83(77)
Large farms	13	12	25	56.88	28.33	85.21	10	8	18 (28)
All farms	36.78	21.55	58.33	37.74	19.66	57.4	9.63	4.3	13.93(75.7)

Note: *figures in parentheses indicate the percentage decrease in labor utilization in relation to the draught animals operated farms.*

	DAP (N=69)		Mixed (N=268)		Tractor (N=8)			
Variables	Mean	Std.Error	Mean	Std.Error	Mean	Std.Error	F	Sig.
MD	29.43	2.11	37.58	1.48	9.62	.73	8.621***	.000
OD	22.01	1.59	19.39	.67	0.00	.00	13.41***	.000
TL	51.44	3.25	56.97	1.98	9.62	.73	9.437***	.000

Source: Computed from own survey data. *** *Significant at 1 percent level.*
Note. *MD= man day, OD= oxen day, TL= total labor*

The average total labor employment per farm on only draught animal power, mixed and only tractor operated farms utilized were 58.33, 57.4 and 13.93 person-days per farm respectively. The average human labor employment per hectare on tractor farms was 13.93 person-days as compared to 58.33 person-days on only draught animal and 57.4 person-day on mixed farms, which were reduced to about 75.7 per cent on tractorised operated farms.

Hired labor (oxen-day for only dap and mixed) employment per farm showed a positive trend with increase in the farm size for the only draught animal, mixed and tractor operated farms except in large farms of only draught animal power and medium farm of only tractor farm. Family labor tended to increase with increase in the farm size for the mixed and only tractor operated farms. No such relation was, however, observed for the only draught animal operated farms even though the use of family labor (man day labor) and hired labor (oxen day) per farm was much lower on the large farms as compared to the small farms, this because of small number of observation of large farms.

There has been a reduction of total human labor employment to the extent of about 75 per cent on the tractor farms as compared to both the draught animal and mixed farms. There is the displacement effect of tractorization on human labor. Thus, it is clear that tractorization decreased human labor employment according to sample farms. It was concluded that displacement of human labor was significant only on tractor-operated farms in all farms. The vast majority of farmers were

used draught animal power in this study area this is why there was the displacement of human labor on tractor-operated farms.

The Utilization and Per Unit Cost of Tractor Power According to Size of Farm groups.
The unit cost of tractor power according to size of farms were depends on the cost of different type of tillage operation and planting operated cost were employed. The unit costs of tractor power and employment pattern of tractors according to farm size are presented in table below.

Table 21. The utilization and per unit cost of tractor power according to farm size.

Farm size group	Cost of primary tillage	Cost of secondary tillage	Cost of planting	Total cost
Small farms	972.0139	706.25	700	2378.26
Medium farms	1150.968	600	700	2450.96
Large farms	1443.478	600	700	2743.5
All farms	1115.275	600	733.3	2448.57

Farm size group	Cost of 1^0 tillage	Cost of 2^{nd} tillage	Cost of planting	Total cost
All farms	1181.25	706.23	700	2587.5

Farm size group	Operating cost
Small farms	1079.66
Medium farms	1450.96
Large farms	1773.9
All farms	1339.04

Source: Computed from own survey data.

The utilization of tractors cost in all farms together was found to be about 2587.5 ETB .As the result revealed the unit cost of tractor use per year increased with the farm size. The average unit costs of primary tillage for different farm size were about 972, 1150, and 1443 ETB on small medium and large farm size respectively.

The unit cost of planting for different farm size were about 1200 ETB for small farm size and about 700 ETB for both medium and large farm size. The total cost of tractor or the overall operating costs were also increasing with the farm size.

Different Costs and Profits/returns for Different Types of Operated Farms According to the Farm Size groups.
The economic efficiency of tractor use is contingent on the comparative analysis of costs and returns for the tractor operated farms vis-a-vis those for the only draught animal power and mixed operated farms. The net incomes, family labor incomes, and farm business incomes for the sample only draught animal power, mixed and tractor only operated farms of three selected sizes are presented in table below.

Table 22 measures of farm profit for only draught animal power, mixed and for only tractor operated farms of the sample in study area.

	Income (Rs.)							
Farm size	Net			Family labor			Farm business	
Groups	DAP	Mixed	Tractor	DAP	Mixed	Tractor	DAP	Mixed Tractor
Total incomes	10769.7	22568.24	26378.01	11442.8	23402.4	26745.5	20605.1	37522.2 32870.5

Table 23 Farm profit for draught animal mixed and tractor operated farms according to farm size

	Income (Rs.)							
Farm size	Net			Family labor			Farm business	
Groups	**DAP**	**Mixed**	**Tractor**	**DAP**	**Mixed**	**Tractor**	**DAP**	**Mixed Tractor**
Small farm	276.14	217.00	26378.01	293.4	225.02	26745.5	528.3	360.8 32870.5
Medium farm…	398.87	184.98	4396.3	423.8	191.8	4457.6	763.15	307.5 5478.4
Large farm …3589.89		537.33	26378.01	3814.3	557.2	26745.5	6868.38	893.4 32870.5
All farms ……	156.06	84.2	3297.3	165.8	87.3	3344.3	298.6	140.00 4108.8

Source: Computed from own survey data.

Farm mechanization has significantly helped the farming community in the overall economic development of the country. These studies revealed that the net income was higher on tractor operated farms than both mixed and draught animal operated farms. The only exception was the farm business income for the mixed operated farms. The gross income per farm of an average tractor operated farms were 145% and 17 % higher than that of farms using only draught animal and mixed farms respectively. The family labor income per farm of an average tractor operated farms were 134% and 14 % higher than that of farms using only draught animal and mixed farms respectively. The farm business income per farms of tractor operated farms as a group exceeded that of the draught animal operated farms by 60%.

The result also reveals that all the measures of farm returns were higher for the tractor farms of all farm size groups. The difference in all incomes between the tractor and draught animal and mixed operated farms were the highest for all in the farm size groups. There were higher significance differences among the operated farms. It therefore looks that the tractor operated farms were economically more efficient than the draught animal and mixed operated farms especially in the case of farms of small and large farm sizes.

The Major Constraints in Using Tractor and Draught Animal Power.

Table 24 and 25 below shows that high price of tractor from time to time is the most critical constraints to use tractor for operating the land, and shortage of feed for oxen is the serious constraints to using oxen for operating the land.

Table 24 the major constraints in using tractor for operating land.

Tractor use constraints		Freq.	Percent	Cumulative percent
1.	Price of tractor	140	40.58	68.70
2.	No problems	97	28.12	28.12
3.	Shortage of tractor	64	18.55	87.25
4.	Shortage of land	5	1.45	88.70
5.	Brokers problem	5	1.45	90.14
6.	Shortage of budget	10	2.90	93.04
7.	Land fragmentation	24	6.96	100.00
	Total	345	100.00	

Table 25 the major constraints in using oxen for operating the land.

Oxen use constraints		Freq.	Percent	Cumulative percent
1.	No problems	144	41.74	41.74
2.	Shortage of feed	109	31.59	73.33
3.	Shortage of oxen	41	11.88	85.22
4.	Labor intensive	42	12.17	97.39
5.	Time consuming and less production	9	2.61	100.00
	Total	345	100.00	

Source: Computed from own survey data.

According to the survey result, the shortage of feeding and grazing land for oxen, shortage of oxen, and labor intensive were the main constraints to use oxen for plowing their land. Accordingly, about 31.5%, 12.1 %, 11.8% and only about 2.6% of the respondents selected the shortage of feeding and grazing for oxen, labor intensive, shortage of owned oxen and time consuming and less production as the main constraints respectively, while about 41.7% of respondents selected was no problem of using oxen for plowing the land (Table 25).

The result also revealed that the high price of tractor and shortage /unavailability of the tractor on time were the major constraints of using tractor for plowing the land. Accordingly, about 40.5%, and 18.5 % of the respondents selected the price of tractor and shortage of tractor was as the major constraints of using tractor while about 7%, 3 %, 1.4% and 1.4 % of the respondents were as the land fragmentation, shortage of budget, shortage of land and broker problem as the constraints of using the tractor for operation of their land. However, about 28% of the respondents there was no problem of using tractor for operation farms (Table 24).

CONCLUSION AND RECOMMENDATIONS

The result of the study revealed that households' demographic and socio economic characteristics such as average family size of mixed operated farms (7 persons) was marginally smaller than that of only draught animal and only tractor operated farms (8 persons). The only draught animal and tractor farms farmers were mature and had more wheat farming experience, while mixed farms farmers had larger maximum farms and were more educated. Education, family size, land for

wheat, total cultivated land, yield of wheat were significant difference among the types of farms. Most farmers used mixed farms, followed by only draught animals for land preparation and few used only tractors. Land preparation was operated once time by only tractor followed by draught animals three times before sowing. Economically poor households does not use tractor, the only use tractor were model and middle level households.

The percentage area of wheat land were higher for tractor only operated farms and there was the significance difference in the proportions of the wheat area on the all farms of various farm size groups. The cropping intensity of only tractor-operated farms was significantly higher in comparison with the cropping intensity of all farms and only draught animals operated farms. The intensity of cropping had a relationship with the mechanization technologies and it has positive relationship with tractorization.

The yield of wheat crop was relatively better when it was operated by tractor and barley was better by mixed operated farms. That means the average of wheat production in all farms of tractor operated farms were higher (34.67 qt ha^{-1}) than other operated farms. There were the significance differences of wheat yield among different types of farms.

The Tobit model showed that wheat farm land size, tractor use, and labor (man equivalent) for the adoption of the chemical fertilizers, Sex of the household, land allocated for wheat land and tractor use for the adoption of improved seed, and Age of the households and total cultivated land for the adoption of agro chemicals were affect positively and significantly. Therefore, the tractor uses (tractorization) have positively and statistically significant affect the adoption of chemical fertilizers and improved seed rate, except the adoption of agro chemical application.

The average human labor employment per hectare on tractor-operated farms was 13.93 person-days as compared to 58.33 person-days on only draught animal operated farms and 57.4 person-day on mixed farms, which were reduced to about 76.1 per cent on tractorised operated farms. There has been a reduction of total human labor employment to the extent of about 76 per cent on the tractor farms as compared to both the draught animal and mixed operated farms. There is the dislodgment effect of tractorization on human labor.

The net income was higher on tractor-operated farms than both mixed and draught animal operated farms. All the procedures of farm returns were higher for the tractor farms of all farm size groups. There were higher significance differences among the operated farms. Therefore, the tractor-operated farms were economically more efficient than the draught animal power and mixed operated farms especially in the case of farms of small and large farm sizes.
Most farmers used mixed operated farms (tractor plus draught animal operated), followed by only draught animals operated for land preparation and few used only tractors operated, so the government of Ethiopia as well as Oromia regional state should have to provide strong training and extension services on the utilization of mechanization technology. In order to reduce the price of the tractor to plough the land and shortage of tractor on time, the government and the responsible organizations should provide the technologies on time and accessible technology for farmers.

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