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Comparative Advantage of Tractor Utilization in Southeastern Oromia, Ethiopia.

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Abstract:
This study analyzes the 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 was 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 farmland size, tractor use, and labor for the adoption of the chemical fertilizers, land allocated for Wheatland and tractor use for the adoption of improved seed, and Age and total cultivated land for the adoption of agrochemicals affected positively and significantly. Tractorization has a positive and statistically significant effect on the adoption of chemical fertilizers and improved seed rate, except for the adoption of agrochemical applications. The average wheat production in all farms of tractor-operated farms was higher (34.67 qt ha\(^{-1}\)) than other operated 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

Ethiopia has stayed constant with the centuries-old tillage instrument known as the maresha, which is still used to till more than 95 percent of the area under cultivation for annual crops, despite being one of the first in the world to adopt the use of animal power in agricultural production (Goe, 1987 and Ehret, 1997 sited in FAO, 2013a). When we look at the global scenario of agricultural mechanization, especially in Asian countries where it was previously very low, as well as in Africa, we can see that it is rapidly improving in response to rising labor scarcity, greying agricultural populations, rising labor costs, and increasing feminization of agriculture due to the propensity of more men than women migrating to urban areas, as well as the development of modern value chains that respond to increasing labor costs (FAO, 2015).

In most Sub-Saharan African (SSA) countries, farming is returning to hand-hoe and animal-drawn equipment. However, returning to traditional farming methods would not be able to satisfy the population's long-term food needs, as the farm is severely lacking in both human and animal power due to a variety of factors such as prevalent animal sickness, a lack of feed, and pandemic diseases such as HIV. According to recent research findings, one out of every three Ethiopian families has no oxen, while one out of every three households has only one ox (Desalegn R., 2009). Furthermore, the coping mechanism for individuals who had reported "No oxen" was "hand digging" for more than 2.2 million persons, demonstrating the severity of the situation (CSA, 2009). As a result, mechanization proposals could be justified by current animal diseases, a lack of feed, and a shortage of rural labor of the requisite quality and level at the required times. For example, a survey on farming system characterization done in the Arsi zone in 2016 revealed that feed deficit was the top-ranked limitation in animal production, while agricultural farm power shortage was the third-ranked crop production constraint (Tamrat, 2017).

According to FAO STAT, 2012, Ethiopia has the lowest and weakest infrastructural development, as well as one of the lowest levels of mechanized agriculture in the East African (IGAD) area (FAO, 2013b). Ethiopia was ranked 173rd out of 187 countries in 2003, with 2.71 tractors per 100 hectares of arable land, compared to 27.62, 16.27, and 9.04 in...
Kenya, Somalia, and Uganda, respectively. Iceland had the most tractors per 100 hectares of arable land, with 15412.86 tractors, compared to the world average of 50 tractors (http://www.nationmaster.com/country-info/stats/Agriculture/Agricultural_machinery/)

The employment of tractors in underdeveloped nations faced significant difficulties (arguments) from a variety of development practitioners who held two seemingly opposing viewpoints. The replacement impact views and the net contribution views are the two perspectives. A mix of animal power, animal-drawn implements, and manual labor, according to the replacement viewpoint, may accomplish any job that could be performed by a tractor. Factor prices (or factor scarcities) were thought to influence the transition from animal to tractor power (Binswanger. P., 1979).

The "Net contributor" view of tractors is the second viewpoint. This group contends, nearly regardless of factor prices, that power is a key limitation to agricultural production. They claim that a tractor's higher power enables for more thorough or deeper tillage than animal power. Furthermore, tractor-mounted implements acquire a higher level of precession, resulting in larger yields. Furthermore, a tractor may be able to restore terrain that is inaccessible to animals. They also suggest that the increased power and speed would allow for more timely operations, resulting in larger yields and wider use of double cropping. In addition, higher yields and double cropping would lead to higher levels of output that require more labor in operations not performed by the tractor. 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, evidence from worldwide research outputs shows that these two views are not mutually exclusive, but some researchers have gone to great lengths to explain their positions, as in the case of India's net contributor view (S.S. Johl, 1973) and Ethiopia's substitution view (Kifle, 1972 and Holmberg, 1972). When we look at the current scenario in Ethiopia, it appears that the substitution effect theory is being embraced. This may be seen in policy documents, which regard labor as an underutilized and cheapest production factor in agriculture and place a greater emphasis on labor intensity in the agricultural production system. However, there are two ways to look at the importance of tractorization in Ethiopian agriculture. The first one is the current feed shortage/price for draught animals and the other one is a shortage of family labor because of sending children to school.

The main objective of this study was to analyze the economics of tractorization and compare it with animal draught power. Moreover, the specific objectives were to analyze the 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; and 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 the 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 systems. Mechanization has also a long history in these areas starting from the imperial regime when CADU and ARDU programs 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°45’N to 8°58’N latitude and 38°32’E to 40°50’E longitude (Atlas of Arsi zone, 2002). It has also a surface area of about 20,737.24 km² (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 systems create wider opportunities for having a long history for the 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 a 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 the zonal agricultural development office, typical highlands of some districts like Asasa have more mechanized with the wheat production from the zone.
Bale zone in the south-eastern part of Oromia regional state. It located between the latitude of 5°22' - 8°08' N and longitude 38°41' - 40°44' E. Bale zone have eighteen administrative districts and two administrative town which is Bale robe and Goba town. The zone has also diverse agro-climatic conditions for the production system, so it also creates good opportunities for mechanization purposes; especially Sinana woreda is more mechanized among the existing woreda of the Bale zone.

**Sampling Methods and Sample Size**

The 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 the zonal/regional average of farmland 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 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.

\[
Cropping\ Intensity\ (CI) = \frac{\text{Gross cropped area}}{\text{Net Sown Area}} \times 100
\]

The intensity of cropping was calculated as the percentage ratios of cropped to total cultivated areas per farm while mean comparisons were employed to compute the effect of tractorization on the yield of major crops (Wheat and Barley).

To capture the effect of tractor use on the adoption of improved major agricultural inputs Tobit model was employed. The effect of tractorization on human labor employment data on plot size-based inventory of labor was 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 was 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. The 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,
\[ GM = TR - TVC \] \hspace{1cm} (2)
\[ NFI = GI - TC \] \hspace{1cm} (3)
\[ TC = TVC + TFC \] \hspace{1cm} (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 the value of hired human labor, the value of hired and owned oxen/tractor labor, the value of the seed, the value of fertilizers, the value of pesticides, the value of weedicides, and land revenue.
- (ii) Cost A\(_2\) includes cost A\(_1\) plus rent paid for leased inland
- (iii) Cost B is cost A\(_2\) plus the 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 the effect of tractor use on the adoption of major agricultural inputs. There is a broad class of models 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 a model a limited dependent variable model because of the restriction put on the value taken by regressed (Gujarati, 2003). The selection of an econometric model requires taking into account the nature of the dependent variable, among others. A dependent variable that 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:

\[ Y^* = \beta_0 + \beta X_i + U_i \]
\[ Y = Y^* \text{ if } \beta_0 + \beta X_i + U_i > 0 \]
\[ Y_i = 0 \text{ if } \beta_0 + \beta X_i + U_i < 0 \] \hspace{1cm} (5)

Where,
- \( Y \) = the observed dependent variable
- \( Y^* \) = latent variable (which is not observable)
- \( X_i \) = Vector of explanatory variable
$\beta =$ vector of parameters to be estimated

$U_i =$ 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)].

$$L = \Pi \frac{1}{\sigma} f\left(\frac{y_i - \beta_i \times 1_i}{\sigma}\right) \Pi F\left(\frac{-\beta_i \times 1_i}{\sigma}\right) \tag{6}$$

Where $f$ and $F$ are respectively, the density function and cumulative distribution function of $Y_i^*$, $\Pi y_i^*>0$ means the product over those $i$ for which $y_i^*>0$, and $\Pi y_i^* \leq 0$ means the product over those $i$ for which $y_i^* \leq 0$.

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 $X_i$ (explanatory variables) has two effects. It affects the conditional mean of $Y_i$ 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:

$$\frac{\partial E(Y_i)}{\partial (x_i)} = F(z)\beta_i \tag{7}$$

Where, $\frac{\beta_i \times 1_i}{\sigma}$ is donated by $Z$,

The Change in the probability of adopting technology as an independent variable $X_i$ change is:

$$\frac{\partial F(z)}{\partial (x_i)} = f(z)\frac{\beta_i}{\sigma} \tag{8}$$

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 a normal curve, is a vector of Tobit maximum likelihood estimates and $\sigma$ 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 number of chemical fertilizers, improved seed rate and Agrochemicals (Herbicides, Weedicides, and Pesticides) applied and are described as follows;

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

2. **Improved seed rate:** it is the amount of improved seed that farmers are using per 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.

3. **Agrochemical application:** it is the number of different agrochemical applications that means herbicides, weedicides, and pesticides that farmers are using per hectare of land and continuous variable measured in terms of litter.
RESULTS AND DISCUSSION

This section presents the results of the analyses of the cross-sectional survey data of the study. Descriptive statistics on the socio-economic profile of households and econometric estimation results of the analyses of the effect of tractor utilization compared to 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. The 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 households 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.

| Variables           | DAP (N=69) |          | Mixed (N=268) |          | Tractor (N=8) |          | F    | Sig.           |
|---------------------|------------|----------|---------------|----------|---------------|----------|------|----------------|
|                     | Mean       | Std.Error| Mean          | Std.Error| Mean          | Std.Error|      |                |
| 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       |
| CultivatedLand      | 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.
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.

The land is the utmost important resource in farming professionals 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 purposes was 0.25, 0.2, and 0.42 hectares, and the maximum size of the 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 hectares for only draught animal power used, 2.2 hectares for mixed operated farms, and 2.4 hectares 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. In addition, the 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 | DAP farm | mixed farm | Tractor farm |
|-------------|-----|---------|------------|----------|------------|--------------|
| Model       | 62  | 17.97   | 17.97      | 9        | 50         | 3            |
| Middle      | 254 | 73.62   | 91.59      | 48       | 201        | 5            |
| Resource poor | 29  | 8.41    | 100.00     | 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 farmers, 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) |

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

**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 tractors 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 tractors 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)         | 139   |
| Asasa            | 59 (45.4)         | 130   |
| Sinana           | 24 (31.6)         | 76    |
| Total            | 144 (41.7)        | 345   |

Table 7 shows that in all sample districts, a larger proportion of households owns landholding size ranging from 2 to 4 hectares. The household percentage in Hexosa, Asasa, and Sinana districts in this landholding class was about 44, 47 and 43 percent’s, respectively. The highest percentage of households (40.3 percent) was found in the Hexosa district, and the smallest percentage of households (22%) was found in the 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 percentage 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 | Types of Farms               | Total |
|------------------|------------------------------|-------|
|                  | Only DAP used                |       |
|                  | Tractor +DAP used ( Mixed)   |       |
|                  | Only Tractor used            |       |
| Small farm       | 39                            | 104   | 1 | 144 |
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                     | 226.81              |
| 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 cropland 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                                         |
According to local and zonal offices of agriculture and natural resource development, the farmers or households are generally classified as small, medium, and large farmers in terms of their farmland 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 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 a significant 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 a 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 animals, mixed and only tractor operated farms in the sample are shown in the table below. The study revealed that only tractor-operated farms had a higher cropping intensity of 91.6 percent 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 a positive relationship with tractorization. There was a significant difference in cropping intensity at 1 percent among the types of operated farms.

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

| Types of Farm | Cultivated area | Cropped area | Intensity of cropping (%) |
|---------------|-----------------|--------------|--------------------------|
|               | Per farm        | per farm     |                          |
| DAP           | 132.88          | 97.65        | 73.48                    |
| Mixed         | 674.75          | 596.13       | 88.34                    |
### 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          | Wheat production (qt/farm) | Barley production (qt/farm) |
|--------------------|---------------------------|-----------------------------|
|                   | DAP       | Mixed      | Tractor | 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          | 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.

| Farm size | Yield of Wheat | Yield of Barley |
|-----------|----------------|-----------------|
|           | DAP       | Mixed | Tractor | DAP       | Mixed | Tractor |

Source: Computed from own survey data.
According to the result, average yield of wheat was the highest (38.09 qt ha⁻¹) in small farm by only tractor-operated farms. However, 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 percent 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.

| Variables     | DAP only | Mixed | Tractor only |
|---------------|----------|-------|--------------|
| Seed kg/ha    | 204.71   | 226.86| 162.5        |
| Dap kg/ha     | 98.91    | 128.73| 112.5        |
| Urea kg/ha    | 67.39    | 76.58 | 75           |
| NPS kg/ha     | 5.07     | 12.12 | 18.75        |
| Herbicides (lit/ha) | 1.38   | 1.34  | 1.06         |

Source: Computed from own survey data

*** Significant at 1 percent level.
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 percent 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 a significant difference of seeding rate per hectare of tractor use and other operated farms. Moreover, no significant difference of urea kg per hectare, herbicides litter per hectare, and pesticides litter per hectare among the operated farms, but there were significant differences 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 to improved seed every year 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 the adoption of major agricultural inputs (chemical fertilizers, improved seeds, and agrochemicals). The estimations of parameters of the variables expected to influence the adoption of major agricultural inputs are presented in 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 the Table below give the maximum likelihood parameter estimates of the number of chemical fertilizers applied.

Table 17 Maximum Likelihood Estimates for the Tobit model for Chemical fertilizers

| 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 |
The results show that wheat farmland size (LNSWHT) had statistically significant and positively influences at 10 percent level on the adoption of use of fertilizer, which means that an increase in wheat farmland size by 1 ha increases the probability of using the fertilizer by 169.7 percent; This implies that farmers with larger wheat farmland 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) was found to be a positive and significant influence on the likelihood of adoption of using fertilizer at a 5 percent significance level. The results computed indicated that increase having access to a tractor by 1 percent increases the probability of adoption of fertilizer by 158.8 percent. Having extension contact (EXTCNT) has been a negative and statistically significant variable in determining adoption of fertilizer at a 5 percent significance level, which implies a decrease in contact with extension agent decreases the probability of adoption of fertilizer by 49.7 percent. This is because the frequency of contact with extension agents decreases the probability of acquiring up-to-date information on the new agricultural technologies.

Members of cooperatives (MEMCOOP) have been negative and statistically significant variable in determining adoption of fertilizer at a 10 percent significance level, which implies a decrease in members of cooperatives decreases the 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 a 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 laborers 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 labor and thereby enables the household to purchase and use more fertilizer. Generally, the Tobit model results of this study revealed that a unit increase in the explanatory variable will bring a certain percent of change or increases on the probability of adopting 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

| Variables  | Coef.   | Std. Err. | t    | P>|t|   | dy/dx    |
|------------|---------|-----------|------|-------|----------|
| SEXHH      | 27.1097 | 14.58416  | 1.86*| 0.064 | 27.1097  |
| AGEHH      | -.191205| .2642193  | -0.73| 0.468 | -.191205 |
| 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 |
The Tobit model result shows that sex of household head, land allocated for wheat, and tractor use have a 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.

The 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 a 27.1% higher probability of participation than female-headed households. In fact, in the study districts, authorizing females to be household heads 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 the 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 farmland 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 farmland size by 1 ha increase the probability of adoption of improved seed rate by 19.9 percent; This implies that farmers with larger wheat farmland size adopt more using improved seed rate. Tractor user (TRCTRUSE) was found to be a 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 the adoption of improved seed rates and is statistically significant at 1 percent level of significance. The magnitude of negative signs shows that farmers who are not visited by extension agents, keeping other things constant, have a 9.5 percent lower probability of adopting improved seed rate unlike non-contracted farmers with extension agents.

**Effect of Tractorization on Adoption of Agro chemicals application**

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

| 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  |
The result of the model showed that the age of the household head had a significant 10 percent level with a positive relationship. A one-year increase in the respondent's age increases the likelihood of using the 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 the total cultivated land or land holding size of the household head (CULT LND) had a statistically significant and positively influenced adoption of different chemical applications at a 1 percent level, which means that an increase in cultivated farmland size by 1 ha increases the probability of using the chemical application by 3.8 percent. This implies that farmers with larger cultivated farmland sizes adopt more agrochemical applications.

Wheat farmland size (LNSWHT) had a statistically significant and negative influence on agrochemical application adoption at a 1% level, which means that a decrease in wheat farmland size by 1 ha reduces the probability of using the agrochemical application by 3.7 percent, implying that farmers with smaller wheat farmland sizes use fewer agrochemical applications. Tractor users (TRCTRUSE) had a negative and significant influence on the adoption of agrochemical applications at a 10% significance level. The results computed indicated that a decrease in access to tractors by 1 percent decreases the probability of adoption of agrochemical applications by 1.9 percent.

The number of plots and the size of the farmer’s holdings were other variables that determined the adoption of agrochemical applications. At a 1% significance level, the number of farm plots (PLTSIZE) had a negative and significant influence on the adoption of various agrochemical applications. This implies that the number of farm plots is a measure of farm disintegration and those farmers who have a lower number of farm plots have less interest in adopting different agrochemical applications.

**Effect of Tractorization on Human Labor Employment.**

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

| Farm size groups | DAP only | Mixed | Tractor only |
|------------------|----------|-------|--------------|
|                  | 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) |

*Source: Computed from own survey.*

**Note:** *** and * indicate the level of Significance at 1, and 10 percent, respectively.
Note: figures in parentheses indicate the percentage decrease in labor utilization in relation to the draught animals operated farms.

| Variables | DAP (N=69) | Mixed (N=268) | Tractor (N=8) |
|-----------|------------|---------------|---------------|
|           | 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 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, compared to 58.33 person-days on only draught animals and 57.4 person-days on mixed farms, with tractor-operated farms accounting for approximately 75.7 percent of the total. Hired labor (oxen-day for only dap and mixed) employment per farm showed a positive trend with an 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 farms of only tractor farms. For mixed and only tractor-operated farms, family labor tended to increase with farm size. No such relationship 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 was because of the small number of observations of large farms.

Total human labor employment on tractor farms has decreased by approximately 75 percent when compared to both 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. The vast majority of farmers used draught animal power in this study area. This is why there was a displacement of human labor on tractor-operated farms.

The Utilization and Per Unit Cost of Tractor Power According to Size of Farm.

The unit cost of tractor power according to the size of farms depended on the cost of different types of tillage operation and planting operated costs were employed. The unit costs of tractor power and employment pattern of tractors according to farm size are presented in the 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 1st tillage | Cost of 2nd 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 sizes were about 972, 1150, and 1443 ETB on small, medium, and large farm sizes respectively. The unit cost of planting for different farm sizes was about 1200 ETB for small farm sizes and about 700 ETB for both medium and large farm sizes. The total cost of a 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.

| Farm size Groups | Income (Rs.) | Net         | Family labor | Farm business |
|------------------|--------------|-------------|--------------|---------------|
|                  | 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

| Farm size Groups | Income (Rs.) | Net         | Family labor | Farm business |
|------------------|--------------|-------------|--------------|---------------|
|                  | DAP          | Mixed       | Tractor      | DAP           | Mixed        | Tractor      |
| Small farm       | 276.14       | 217.00      | 26378.01     | 293.4         | 225.02       | 26745.5      |
| Medium farm      | 398.87       | 184.98      | 4396.3       | 423.8         | 191.8        | 4457.6       |
| Large farm       | 3589.89      | 537.33      | 26378.01     | 3814.3        | 557.2        | 26745.5      |
| 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 on 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 average tractor-operated farms was 145% and 17% higher than that of farms using only draught animals and mixed farms, respectively. The family labor income per farm of an average tractor-operated farm was 134% and 14% higher than that of farms using only draught animals and mixed farms, respectively. The average farm business income per farm 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 than for all other farm size groups. The difference in all incomes between the tractor and draught animal and mixed-operated farms was the highest of all in the farm size groups. There were more significant differences among the operated farms. It therefore looks like 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.

Tables 24 and 25 below show that the high price of a tractor from time to time is the most critical constraint to using a tractor for operating the land, and shortage of feed for oxen is the serious constraint to using oxen for operating the land.

Table 24 the major constraints in using tractors 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 results, the main constraints to using oxen for plowing their land were a lack of feeding and grazing land for oxen, a scarcity of oxen, and labor-intensive practices. 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, time-consuming, and less productive as the main constraints, respectively, while about 41.7% of the respondents selected there was no problem with using oxen for plowing the land (Table 25).

The results also revealed that the high cost of the tractor, as well as its scarcity or unavailability on time, were the major constraints of using the tractor for plowing the land. As a result, approximately 40.5% and 18.5% of respondents chose tractor price and tractor shortage as the major constraints of using the tractor, respectively, while approximately 7%, 3%, 1.4%, and 1.4% of respondents chose land fragmentation, budget shortage, land shortage, and broker problem as the constraints of using the tractor for land operation. However, about 28% of the respondents said there was no problem with using tractors for operation farms (Table 24).

CONCLUSION AND RECOMMENDATIONS

The result of the study revealed that households’ demographic and socio-economic characteristics such as the average family size of mixed-operated farms (7 persons) were marginally smaller than that of only draught animals 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, a yield of wheat were significant differences 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 tractors followed by draught animals three times before sowing. Economically poor households do not use a tractor, the only used tractor were model and middle level households.
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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Appendix 1.

**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)