



## FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

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# Socio-economic analysis of conditions for adoption of tractor hiring services among smallholder farmers, Northwestern Ethiopia

Astewel Takele<sup>1\*</sup> and Yihenew G. Selassie<sup>1</sup>

**Abstract:** The objective of the study was to understand the socio-economic and cultural conditions of crop cultivation practices of farmers; the willingness of farmers towards tractor use and the factors that affect the start of tractor hiring services (THS). A total of 148 households were considered for the survey. Both purposive and stratified sampling techniques were employed disaggregated by sex, wealth status and soil types owned. Data collection techniques included structured interview and focused group discussion. Both descriptive and econometrics techniques were employed to analyze the data. The findings showed that labor shortage (69.7%), high rate of weed infestation (26.5%) and shortages of herbicides (27%) were the main challenges of weeding in the study area. Likewise, shortage of oxen (52%) and labor (43.3%) were found to be challenges related to ploughing practice. About 80% of the sampled farmers were willing to use THS if available in the study area. The econometric model result showed that being a model farmer, sex of a household, land holding, adult female labor endowment, oxen endowment and experience in use of herbicides were positively and significantly affecting farmers' willingness to use THS. However, age of the head of a household negatively affected the willingness to use THS. From the results of the study it is possible to conclude that since

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### PUBLIC INTEREST STATEMENT

An increasing number of Ethiopian farmers are not able to maintain a pair of oxen. Tractor hiring service (THS) is an alternative option for farmers who rely on agriculture. Hence, a better understanding of the socio-economic and cultural conditions of cultivation practices of farmers is the conditions for successful introduction of a tractor hiring service. Small farmers who rely on oxen of others for land preparation cannot plough at the right time. Therefore, integrating motorized technology with draught animal technology is a public interest especially for private investors, female poor households. This study highlights the socioeconomic factors that inhibit farmer's willingness to use THS. The result showed that the socioeconomic characteristics of households like being model farmer, sex of households, age of the household, land size, oxen ownership, availability of female adult labor and herbicide usage were the main factors that affect the introduction of THS in the study area.

oxen ownership and oxen ploughing practice are deeply rooted in Ethiopian tradition, awareness creation and close follow up are required at all levels for adoption of mechanization.

**Subjects: Development Studies; Development Policy; Economics and Development**

**Keywords: adoption; tractor hiring service (THS); Ethiopia**

### 1. Background

Farm power in African agriculture, especially Sub-Saharan Africa (SSA), relies on human and animal power based on operations that depend on the hoe and other hand tools (FAO and UNIDO, 2008). Moreover, agricultural mechanization in sub-Saharan Africa has largely ignored the role of the capital service market in spreading the use of mechanical technologies (Adamade & Jackson, 2014; Houssou, 2015). In most African countries, draught animal power has been used for centuries. The African farmers are generally referred to as “hoe farmers”. FAO estimated that, in the late 1990s, 65% of cultivated area in sub-Saharan Africa was prepared by hand, 25% by draught animals and 10% by tractor (FAO, 2013). Sub-Saharan Africa continues to have very low levels of mechanization with declining levels of adoption (Pingali, 2007). The percentage of the productive land that is tilled using motorized traction remains very low in Sub-Saharan African and estimates range from 1 to 4% (FAO, 1998). Several African governments are showing efforts to improve their mechanization policies. For instance, the government of Mali imported 400 tractors from India in 2006 and in 2013; the government of the Democratic Republic of Congo imported 920 sets of tractor and farm equipment from India (FAO, 2013); and Ethiopia imported 2940 tractors in 2013 (CIMMYT, 2014).

In Ethiopia, farm power at smallholder level is almost exclusively obtained from animal draught power. Draught animal technology in Ethiopia has been an integral component of farming system for 3000 years (Melaku, 2011). Hence, soils in Ethiopia are traditionally ploughed repeatedly with an oxen-drawn plough called *Maresha* (a plough made from a piece of iron and wood) before sowing (Panin, 1994). Its simplicity, light-weight and the low cost makes *Maresha* to be popular by small scale farmers of Ethiopia (Melesse, 2000).

Almost all farmers own this simple implement. However, only about one third of all highland farmers own two oxen. An increasing number of farmers are not able to maintain a pair of oxen. About 29% of Ethiopian farmers have no oxen, 34% have one, 29% have two and 8% have two or more. Hence, more than 60% of the farmers have to rent in or borrow one or two animals for cultivation (Melaku, 2011). Ethiopia has 6 million draught oxen (equivalent to 500,000 tractors with 80 horse powers). However, an additional 6 million oxen are required to meet demands. One of the main reasons for reduced oxen ownership is the reduced farm size, resulting in reduced fodder availability to feed oxen and other livestock (Panin, 1994). A pair of oxen consumes about nine tons of forage per year. With increased land use, there is less communal land for grazing and raising livestock, especially in densely populated areas. The increase in demand of beef also triggered farmers to sell oxen after fattening.

Small farmers who rely on oxen of others for land preparation cannot plough at the right time (due to short preparation time at the onset of the rainy season) and pay between one quarter and half of their output of cereals and pulses for hiring a pair of oxen. Access to oxen can be seen to be more important than land size in the Ethiopian context; because without the oxen, the land cannot be cultivated. It is also more difficult for farmers without oxen to intensify production, as a part of the surplus is reserved for the oxen owner (Panin, 1994).

Improved equipment for animal traction has been pursued by research, but with little effects. The Ethiopian government promotes row seeding of teff with reduced seed rate (Melesse, 2000) which requires mechanized seed drilling. Moreover, this requires better seedbed preparation than possible

by traditional *Maresha* plough. At the end, implements for row seeding and mechanical weeding that fit to oxen plough are not still available.

Short term strategies could be to invest in animal feed and health schemes for oxen, and a long term solution could be an establishment of national animal power development program or integrating motorized technology with draft animal technology. Otherwise, shortage of animal power could severely reduce crop production (Melaku, 2011). To increase production and productivity, use of tractor services is an alternative strategy for food security and sufficiency (ATA, 2014). Many researchers debated on use of tractor for small holder farmers, because it affects a households' labour economy (Panin, 1994) and total crop output (the gross value from all crops grown and harvested by household) and crop income or cash receipts (Ulluwishewa & Sakai, 1987). Nevertheless, benefit of using tractors is the gain in timelines (Panin, 1994), selective use of mechanization technologies could increase the technical efficiency of the smallholder through increasing the labor and land productivity (Dagninet & Wolelaw, 2014). Besides, group hiring tractors and custom hiring system is a solution for small holder farmers compared to owning a tractor due to cost, price and availing non-farm employment opportunities (Mabuza, Sitholeb, Walea, Ortmanna, & Darrocha, 2012; Singh, Kingra, & Sangeet, 2013). It is also believed that access of tractors by small-scale farmers through hire services is appropriate option for commercial interests (IFPRI, 2015). The objective of this research was, therefore, to exploring the socio-economic and cultural factors that influence the use of mechanized farming and identify conditions to use tractor hiring service to farmers are identified.

## 2. Methodology

### 2.1. The study area

The survey was conducted in selected three capacity building for scaling up of evidence based best practices in agricultural production in Ethiopia (CASCAPE) project intervention rural Jigna, Tegel wedefit and Ahuri keltafa *Kebeles* (lowest administrative unit in Ethiopia) of Dera, Mecha and Achefer districts, respectively. These *kebeles* are potential producers of crops in Amhara National Regional State and in Ethiopia in general. About one third of the national production is produced in Amhara Region. Jigna *kebele* is suitable for agriculture and located 45 km north of Bahir Dar, capital of Amhara Region. The topography of the *Kebele* is 100% plain and the soil type is Vertisols (black cotton soil). The annual maximum and minimum rainfall of the *Kebele* are 1,200 to 1,000 mm, respectively. Tagele wedefit *kebele* is located at about 10 km away from *Merawi* town in the north direction. The color of the soil is 96% red soil (Nitisols), 2% brown (Cambisols) and 2% black soil (Vertisols). Ahuri Keltafa *Kebele* is located at about 6 km away from *Durbete* town in the north direction. The soils in the study area are Vertisols and Nitisols.

In the study area, mixed farming practice, crop production and livestock rearing is common and supplementary irrigation practice is used during dry season. The common dominant crops grown in the area are maize, rice, vegetables (mainly onions), finger millet, *teff*, chick pea, potato and other commercial crops.

### 2.2. Sampling techniques

To provide insights prior to the main sampling, discussions were made with district experts from the respective district office of Agriculture to make clear the purpose of the study and seek their assistance. The study area was potential producers of food crops in Amhara region (North West Ethiopia) and a potential area for irrigation use due to the presence of Lake Tana, Koga irrigation scheme and several rivers.

A total of 5,154 households (HHs) are available in Tagele wedefit (1558 HHs), Ahuri keltafa (2104 HHs) and Jigna (1492 HHs) *kebeles*. A two stages sampling technique was made by selection of districts at the first stage followed by selection of *Kebeles*. A proportional random sampling technique was used to identify the respondents and a total of 148 HHs were selected for the study. To estimate the sample size the following formula was used (Yamane, 1967).



$$n = \frac{N}{1 + N(e^2)}, \quad (1)$$

where,  $n$  is the sample size,  $N$  is the population size and  $e$  is the level of precision.

The sample respondents were selected based on the pre-defined criteria. The criteria were wealth class (richer if the household owns two or more oxen and poor if households own one or no ox, gender composition (the project demands participation of 30% of women in every activity), soil type (black and red), crop type (maize and rice potential districts), accessibility for tractor intervention, and potentials for agricultural production. Some of the limitation of this study is that districts were selected purposively as it is a potential area in the region that fits the tractor technology and had experience in use of state farms in the past time.

### 2.3. Data collection methods

Both primary and secondary data were collected from the sample households. During the exploratory survey, discussion was held with experts at *kebele* level working in the area to collect relevant information on major aspects of mechanized farming intervention. For the study, about 48 respondents from each *kebele* and a total of 148 respondents from the three *kebeles* were used.

The questionnaires were designed to collect both qualitative and quantitative data. It included household characteristics, livestock ownership, description of weeding and ploughing practices and past experience in relation to mechanized agriculture. The questionnaire was pre-tested for its validity before the actual survey was conducted. This is mainly by experts and with supervision of main investigators on the field. As a result, some questions were modified. Moreover, focus group discussion was conducted in the three districts to supplement the data obtained during the main survey and arguments of the results. The main discussion themes were traditional practices of oxen ploughing (What is the role of oxen? What are the implications of having (a pair of) oxen in the community on social status? What are the main challenges of traditional ploughing and weeding practices? and what are the specific arrangements for accessing oxen/draft power in your community?

The focus groups consisted of about 8–14 farmers each. Such group discussions were done mainly with informal social groups like *Idir*, self help local association, common interest groups (CIG) and elderly resource persons whose livelihood is based on agriculture. Besides, there was also group discussion with cooperative members and representatives of microfinance institutions in the study area. Secondary data on socio-economic characteristics of the study area, soil type, demographic characteristics, major crops grown, and other issues were collected from published and unpublished documents and reports from relevant organizations.

### 2.4. Methods of data analysis

For socio-economic data, descriptive statistics (mean and standard deviation) and for focus group discussions, pair wise ranking were used to identify potential challenges of farm households in each *Kebele*. To study willingness of farmers towards using/hiring tractor service, logistic regression model was applied. The econometric specification largely depends on the purpose of the study and the type of data available. The popular models which are used for different qualitative dependent variables are binary logit, probit, multinomial and ordered logit/probit models. Logistic and probit formulation is quite comparable, with the main difference being that the former has flatter tails that is the normal curve approaches the axis more quickly than the logistic curve. Hosmer and Lemshew (1989) pointed out that a logistic distribution (logit) has got advantage over the others in the analysis of dichotomous outcome variable in that it is flexible and easier used model from mathematical point of view and results in a meaningful interpretation. When the dependent variable has more than one outcomes, multinomial logit or probit model is appropriate however, if the dependent variable has an ordering, ordered logit or probit model is applicable (Gujarati, 2004).

Logistic regression model is a non-linear model where the outcome is measured with a dichotomous variable when there are only two possible outcomes. We predicted the value of the outcome variable (Y) from the predictor (s) (X). Logistic regression is based on odds rather than probability. The advantages of the logistic function are that it yields probabilities are between 0 and 1 and do not make any assumption of normality, linearity and homogeneity of variance for independent variables (Gujarati, 2004).

For this study, the dependent variable is farmer tractor hiring service. Farmers were categorized into farmers using tractor hiring service (1) or not (0). The cumulative logistic probability function is specified econometrically as the follows:

$$p_i = F(Z_i) = F \left[ \alpha + \sum_{i=1}^n \beta_i X_i \right] = \left[ \frac{1}{1 + e^{-(\alpha + \sum \beta_i X_i)}} \right] \quad (2)$$

where,

$p_i$  = the probability that  $i$ th farmer is made a certain choice (using or not using) a given  $X_i$ ,

$X_i$  = represents the  $i$ th farmer explanatory variables,  $i = 1, 2, 3 \dots, n$

$Z_i$  = a linear function of  $n$  explanatory variables ( $X_i$ ),

$e$  = represents the base of natural logarithms (2.718)

$\alpha$  and  $\beta_i$  are regression parameters to be estimated, where  $\alpha$  is intercept and  $\beta_1, \beta_2 \dots \beta_n$  are slope coefficients of the explanatory variables in the model.

The odd ratio implies the probability ( $p_i$ ) that an individual would choose an alternative to the probability ( $1-p_i$ ) that he/she would not choose it.

$$1 - p_i = \frac{1}{1 + e^{Z_i}} \quad (3)$$

$$\frac{p_i}{1 - p_i} = \left[ \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} \right] = e^{Z_i} \quad (4)$$

$$\frac{p_i}{1 - p_i} = \left[ \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} \right] = \quad (5)$$

$$Z_i = \ln \left[ \frac{p_i}{1 - p_i} \right] = \ln e \left[ \alpha + \sum_{i=1}^n \beta_i X_i \right] \quad (6)$$

$$Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + u_i \quad (7)$$

### 3. Results and discussion

#### 3.1. Household characteristics

The result from descriptive analysis shows that 33.3% of the sample respondents have less than one ox (categorized as poor); whereas about 67% of the respondents have two and more oxen (belonging to better-off group). This is twice as high as the national average, where only 30% of the farmers own 2 or more oxen (Melaku, 2011). Hence, the sample was biased towards better off farmers (Table 1).

**Table 1. General description of target households in the sample kebeles (average)**

Characteristics	Kebeles						F-test
	Jigna		Tagel Wedefit		Ahuri Keltafa		
	MHH	FHH	MHH	FHH	MHH	FHH	
Model farmers (%)	87	58.80	60.70	36.80	82.90	14.30	20.05***
Age of house holds	42.58	37.87	42.38	40.16	44.71	44	4.56**
Family members	5	2	7	4	7	4	1.77
Adult labor available	4.23	2.29	3.48	1.78	3.97	2.57	31.13***
Land size in hectare	1.41	0.6	1.1	0.88	1.26	0.57	35.12***
Proportion of heavy soil (ha)	0.78	0.69	0.01	0.02	0.03	0	0.40
Farmers having no or one oxen (%)	3.20	82.40	13.20	84.20	12.20	100	175.21***
Farmers having two or more oxen (%)	96.60	17.60	86.20	15.60	87.80	0	
Livestock ownership (TLU)	6.79	1.6	6.17	1.81	6.6	1.28	88.78***
Oxen ownership (number)	3	1	2	1	2	0	1107.23***
Access to credit (%)	100	82.40	89.70	94.40	97.60	85.7	3.20 *
Amount of credit used (Birr)	5056	3167	2565	2394	3590	3750	1.44

Notes: MHH = male headed households; FHH = female headed households; TLU=tropical livestock unit; Birr = Ethiopian currency, 1\$ = 22 Birr.

\*Significant at 10% level of significance.

\*\*Significant at 5% level of significance.

\*\*\*Significant at 1% level of significance.

### 3.2. Ploughing practices

In the study areas, the dominant land preparation method is using traditional *Maresha* plough (Table 2). Ploughing is traditionally the task of men and ploughing by women it is considered as taboo. In most cases, if female household heads (FHH) do not have adult men in the family, either she hires labor for ploughing or share out her land for share crop. In the traditional production of crops, the ploughing frequency of rice ranges between 2 and 5 and that of maize ranges between 2 and 8 times (mean = 3.77 times). It is clear that poor households do not plough as many times as rich households, implying that they face a challenge of finding oxen.

**Table 2. Ploughing frequency of rice and maize among rich and poor farmers**

Frequency of ploughing	Wealth class											F-test	
	Poor HH						Rich HH						
	Male			Female			Male			Female			
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	
Maize crop	6	8	4	5	6	4	6	8	2	6	8	5	18.93***
Ploughing by own oxen	6	8	3	4	5	2	6	8	4	6	8	4	
Rice crop	4	4	4	4	6	3	4	5	3	4	5	4	6.96**
Ploughing by own oxen	5	5	5	3	4	2	4	5	3	4	5	4	

\*\*Significant at 5% level of significance.

\*\*\*Significant at 1% level of significance.

### 3.3. Weeding practices

The farmers responded that weeding is a laborious task compared to other agricultural practices. This is because it takes a lot of time and is tiresome especially when there is severe weed infestation. In the study area, weeding is practiced mostly by the adult male and hired labor. FHH who do not have enough labor available opt to share out their land for sharecrop. The most common weeding method is hand weeding both for better-off and poor households. About 56% of the households apply herbicides combined with hand weeding for maize and rice. FHH are more inclined to use herbicides due to the fact that they have less labor available. Most farmers (73%) use labour exchange mechanisms for weeding. About 100% of the rich FHH and 75% of the poor FHH use labour exchange mechanisms. Besides rich male headed households (MHH) use hired labor and poor FHH sharecrop for weeding labour. The average weeding frequency is three times; however, 84% of the poor households only weed twice. It is apparent that, richer households weed more frequently than otherwise.

### 3.4. Exchange/payment mechanism

In the study area, cash payment for oxen use is not common. About 79.3% of the sample farmers do not have any experience in renting out or paying for oxen hiring. Farmers with more than two oxen usually borrow their oxen to others for free as gesture of help to poor farmers. Hence, the most common exchange mechanism for oxen sharing is in-kind exchange for other oxen or for labor during ploughing or weeding practice. Of the farmers that do not own oxen, 78% responded that they access oxen through in-kind exchange of their labor; and about 9.4% of them exchange for straw and part of harvest to get oxen during ploughing. The in-kind labor exchange in winter is four man-days for one oxen pair/day and two man-days for one oxen pair/day. The monetary exchange rate in winter (birr per oxen pair-day of oxen in winter) is between 100 and 150 Birr (mean = 125 Birr). In summer the monetary exchange rate is expected between 150 and 250 Birr (mean = 192 Birr) (Table 3).

**Table 3. Reasonable price estimate of tractor service**

Response of households		Rich		Poor		F-test
		MHH	FHH	MHH	FHH	
Would it be possible to pay cash at the spot?						
	Yes (%)	27.1	50	85.7	44.8	2.72
	No (%)	72.9	50	14.3	55.2	
	Total	100	100	100	100	
What is an acceptable price?						
	Average price	297.95	237.5	240	270	1.21
	Min.	50	100	200	50	
	Max.	2800	500	330	1500	
	Most frequent (mode)	200	150/200	200	200	
	St dev.	-	126.58	262.29	909.48	

### 3.5. Cultural practices and taboos

Oxen are of vital importance in assuring livelihood security in the Ethiopian highlands, as they can be sold if the family experiences a calamity such as drought. Oxen ownership has many economic benefits: (1) it is a form of asset accumulation in the farming community; (2) oxen fattening is profitable; (3) renting out gives additional income; (4) ploughing on time (or more land) increased the production/productivity; and (5) oxen manure and dung cake are used as organic fertilizer and fire wood. Oxen ownership has social values as well. More than 40% of both MHH and FHH mention that oxen ownership influences partner selection (e.g. a female who has oxen is the one who is preferred for marriage). Oxen ownership increases the social status of a household. A person who owns at least a pair of oxen is the one to be named as the model farmer and receives a high position at village level. There is a general consensus that a farmer who does not plough properly is called “lazy farmer”.



However, if a farmer ploughs his land with a tractor, he or she would be called as an innovator or lead farmer. Households that own oxen are better farmers than households that do not own because those who have oxen plough their land on time. There are no taboos surrounding oxen that prevent the adoption of tractor hiring service.

### 3.6. Challenges in the traditional ploughing and weeding practices

The current ploughing and weeding system is under stress. The main challenges of farmers associated with weeding are labor shortage (43.3%), weed infestation (26.5%) and shortage of herbicides (3.6%). Challenges associated with early ploughing are shortage of oxen (51.8%), and shortage of labor (48.2%). Particularly poor and female headed households face challenges to access oxen to plough on time. The study showed that three quarters of the respondents who do not own oxen, did not plough on time. There is a shortage of oxen, and farmers who do own oxen plough their own plots first before lending their oxen to others. Hence, other oxen-less farmers only plough their land after the others have finished.

### 3.7. Experience and perceptions towards tractor hiring service (THS)

The study showed that 53.5% of the respondents have experience in using a tractor. Among those who have experience, two third are MHH and only one third are FHH. Tractor ploughing experience stems from the *Dergue* regime (previous government) when farmers participated in tractor ploughing in large cooperative farms in *Dera*, *Mecha* and *Achefer* districts. Regardless of their previous experience, 80.6% of the interviewed farmers were positive about trying the tractor hiring service (if available in the area). This implies that one out of five farmers indicated not to be willing to try this service. Farmers expect that the tractor will plough deeper than the traditional *Maresha* plough. Moreover, they expect that the tractor should be able to plough under dry conditions, so that they can plough on time together with those farmers having oxen (Table 4).

**Table 4. Willingness to try THS among different categories of farmers**

Response of households	Rich		Poor		F-test
	MHH	FHH	MHH	FHH	
Willingness to use tractor					
Yes (%)	86.8	100	50	70.3	2.82*
No (%)	13.2	0%	50	29.7	
Total (%)	100	100	100	100	
Why? Reasons were					
1. Destroy the weed because of deep ploughing (%)	41.4	0	0	21.1	
2. Increased production as a result of good plough (%)	6.9	40	50	0	
3. I have no oxen to plough (%)	6.9	20	0	26.3	
4. Able to till very heavy soil in dry condition (%)	20	0	0	0	
5. Alleviate shortage of oxen (%)	13.8	0	50	5.3	
6. Reduce tillage frequency (%)	6.9	20	0	5.3	
7. If it is renting cost affordable (%)	3.4	20	0	36.8	

\*Significant at 10% level of significance.

### 3.8. Determinants of willingness for tractor hiring service

The regression analysis showed that being a model farmer, sex of household, adult female labor endowment, land holding, oxen endowment, proportion of heavy soil, and experience in use of herbicides positively affect farmers willingness to use THS. However, age of household head was negatively affecting the willingness to try the THS (Table 5).

Model farmers, as compared to non-model farmers, were likely to be interested in tractor hiring service ( $p < 0.047$ ). The tractor hiring service needs targets and should start with farmers who are

**Table 5. Results of binary logistic regression for THS**

Factors affecting willingness to try THS	Coef.	Robust std. err.	z	P > z	[95% Conf. Interval]	
Kebele-1	-0.877	1.277	-0.69	0.492	-3.381	1.626
Kebele-2	1.133	1.087	1.04	0.297	-0.997	3.263
Being a model farmer	1.591**	0.801	1.99	0.047	0.022	3.160
Sex of households' head	3.238**	1.568	2.06	0.039	0.165	6.311
Age of households' head	-0.129***	0.043	-3	0.003	-0.213	-0.045
Education of household head	0.048	0.615	0.08	0.938	-1.157	1.252
Total land holding (ha)	2.117**	1.033	2.05	0.041	0.091	4.142
Proportion of heavy soil (ha)	1.647	1.242	1.33	0.185	-0.786	4.081
Male adult labor (number)	-0.210	0.378	-0.55	0.58	-0.951	0.532
Female Adult labor (number)	0.985***	0.338	2.92	0.004	0.323	1.648
Number of oxen owned (number)	1.337**	0.587	2.28	0.023	0.185	2.488
Ploughing frequency (number)	-1.425	1.633	-0.87	0.383	-4.626	1.777
Herbicides use	1.436**	0.704	2.04	0.041	0.055	2.816
Experience in tractor use	1.434	1.166	1.23	0.219	-0.852	3.719
Access to credit	-1.102	2.128	-0.52	0.605	-5.272	3.068
_cons	1.390	3.843	0.36	0.718	-6.142	8.922

Log pseudo-likelihood = -41.844658

Pseudo R<sup>2</sup> = 0.3271

Number of obs = 130

Wald  $\chi^2$  (15) = 37.70

Prob >  $\chi^2$  = 0.0010

\*\*Significant at 5% level of significance.

\*\*\*Significant at 1% level of significance.

model in the area than non-model farmers. This is because, model farmers are well accepted by majority of the farmers and they are eager to use technology than other farmers. This result was in line with the results obtained from Nigeria (Ayandiji & Olofinsao, 2015). It revealed that farmers who were access to extension workers (usually model farmers are eager and willing to accept technology advices) had a positive relationship with adoption mechanization. Similarly the studies from Chinese experience also showed that strong extension services are the major triggering factors in making mechanization available to smallholder farmers (Sims & Kienzle, 2016).

Sex of households similarly affects tractor hiring service positively ( $p < 0.039$ ). It explains that female farmers were more willing to use tractor services as compare to male farmers. This is probably; female farmers are unable to plough their land on time. This result was consistent with studies by Khondoker, Timothy, and Krupnik (2016) which showed that sex of household in Bangladesh has negatively associated with power tiller (tractor).

Age of the households was negatively associated with tractor hiring services ( $p < 0.003$ ). As the age of farmer's increases, the probability of accepting tractor hiring service decreases. Therefore, the youth group is the potential clients for THS service. This result is in line with the study of Tamrat (2016).

Surprisingly, oxen ownership positively influences willingness to try THS ( $p < 0.023$ ). This implies that farmers with more oxen are more willing to try tractor hiring services. Farmers owning many oxen might find it burdensome to keep oxen and are open to alternative options. In line with this, agricultural mechanization in Philippines, for example, was implemented by appropriate combination of hand tools, animal draft and mechanical power technologies for each specific condition which is determined by financial capacity of farmers (Onate, 1992).

The wealth class of the farmer as measured by oxen ownership and other characteristics used by farmers in the study area also positive and were able to use willingness to try tractor service business. It is found that farmers owning two or more oxen were more likely to be willing to try THS than farmers with no or one ox. The report also mentioned that if tractors are available, the oxen could be used for fattening purpose. Hence, the potential clients to start the THS business in the area are rich farmers than poor farmers. Empirical evidence, however, suggests a non-linear relationship between wealth and adoption of new agricultural technologies of maize variety. Within a rural community, households on the lower wealth continuum behave differently from those on the higher level (Augustine, 2008).

Land holding was found to be significantly and positively ( $p < 0.041$ ) influencing the tractor hiring service. Consistent with earlier work on tractor technology use (tractor hiring), land size has impact on use of tractor (Takeshima & Salau, 2010).

The empirical evidence from Swaziland indicated that the use of tractors is significantly influenced by household wealth and size of arable land used by households (Mabuza et al., 2012). On the other hand, per capita household expenditure also affected the marginal adopters and non adopters of similar characteristics in tractor service provisions (Takeshima, 2015). Similarly, censuses findings of Bangladesh indicated that machinery ownership is positively associated with household assets, credit availability, electrification and road density (Mottaleb, Krupnik, & Erenstein, 2016). Farm income and wealth category were the major factors that influence the willingness of the farmers to use tractor services (Tamrat, 2014).

Given that land holdings on customary land are generally small, sparsely distributed and often fragmented, tractor hiring service providers may face relatively high overhead and transaction costs. Similar studies on determinants of mechanization in Nepal also revealed that the amount of inorganic fertilizer used, area under tractor-ploughing, area under pump-set irrigation and landholding size were the variables affecting tractor adoption. On another research work done on tractor use on rice farms in Philippines indicated that small parcels and the prevalence of small farms also make tractor use uneconomical since both two- and four-wheel tractors are indivisible capital-intensive (Celerina & Maranan, 1980).

The availability of female adult labour significantly ( $p < 0.004$ ) affected the tractor hiring services that means more female adult labour has more likely to tray THS. The farmers' tillage practice usually is a tiresome work. Studies from Oromia Region in Ethiopia showed that factors like oxen number, labor availability (hired and family labour) determine willingness to pay for tractor services (Tamrat, 2014). Case studies from India also indicated that as the level of mechanization increased, the draught animal use significantly reduced annually by 6-2%, but use of human labour reduced by 0-18% (Singh, 2006). Similarly, herbicide use of farmers has also a positive association on tractor hiring services ( $p < 0.041$ ). It is indicated that farmers who have the experience in using herbicide are more willing to try tractor hiring services (THS). This is because the cost of inputs influences the use of tractor services. Ploughing frequency on the other hand was not significant variable in the model.

As oppose to the rule of thumb, farmer’s frequency of plowing is negatively related with THS. During focus group discussion, however, farmers explain that most farmers need to plough their plots of land several times because their plot is small and also they do not have other business to engage in; as a result they are less likely to use THS.

The following hypothesized variables were used to analyze factors that affect farmers willingness to use tractor services (kebele, model farmer, sex of HH, age of HH, Education of HH, land size, soil proportion, male and female adult labour, oxen number, ploughing frequency, herbicide use and experience of using Tractor).

The marginal effect of being a model farmer indicated that as compared to non-model farmers, model farmers have 15.8% probability of willing to use tractor services. Similarly, female headed farmers have 1.9% propensities of trying tractor services compared to male headed farmers. However, if age of households increased by one year, the probability of trying THS decrease by 1.5%; i.e. the older the farmers, the less likely to participate in THS. Land holding is an important variable and it is expected that as the land size of the household increases, the probability of using tractor service would increase by 5%. Similarly, the likelihood of adoption of tractor hiring service will increase by 1.6% if one unit increases in female adult labour. Likewise, if households increase oxen ownership by one unit, the probability of using THS will again increase by 5%. Farmers who use herbicides will have a 3.4% of probability of using tractor hiring services than non-users (Table 6).

**Table 6. Marginal effects of different variables on use of THS**

Variables	Variable dy/dx	Std. err.	z	P > z	[95% C.I.]		X
Kebele-1*	-0.075	0.138	-0.54	0.586	-0.346	0.196	0.308
Kebele-2*	0.074	0.058	1.27	0.202	-0.040	0.188	0.346
Farmer who belong to model	0.158	0.094	1.67	0.094	-0.027	0.343	0.700
Sex of households' head*	0.167	0.071	2.35	0.019	0.028	0.306	0.277
Age of households' head (years)	-0.009	0.004	-2.43	0.015	-0.017	-0.002	42.469
Education of households' head	0.003	0.045	0.08	0.939	-0.086	0.093	1.054
Total land holding (ha)	0.155	0.078	2	0.045	0.003	0.308	1.081
Proportion of heavy soil (ha)	0.121	0.098	1.24	0.216	-0.071	0.313	0.256
Male adult labor (number)	-0.015	0.027	-0.56	0.574	-0.069	0.038	1.362
Female Adult labor (number)	0.072	0.030	2.41	0.016	0.014	0.131	1.369
Number of oxen owned (number)	0.098	0.050	1.97	0.049	0.001	0.196	1.615
Ploughing frequency (number)	-0.105	0.117	-0.89	0.372	-0.334	0.125	1.515
Herbicides use*	0.122	0.057	2.13	0.034	0.009	0.234	0.585
Experience in tractor use*	0.116	0.092	1.27	0.205	-0.063	0.296	0.546
Access to credit*	-0.054	0.063	-0.86	0.392	-0.177	0.069	0.962

\*dy/dx is for discrete change of dummy variable from 0 to 1.

### **3.9. Conditions for adoption of tractor hiring service**

The survey result indicates that there is a promising situation that the farmers would accept or try tractor hiring services. About 80% of the sampled farmers are willing to use tractor use /hiring services. Out of these farmers, about 88% of rich farmers and 66% of poor farmers are willing. However, there are several considerations to take into account before introducing the service to farmers that include:

- (1) Farmers have particular expectations regarding the quality of tractor ploughing. Given the particular climatic conditions, the need for tractors for ploughing is highest at the first ploughing. In Amhara Region, this is in November (for maize) or in March (for rice). The tractor should perform well under dry conditions. Moreover, the ploughing with tractor should be deeper and reduce weed infestation. Given the challenges in weeding, it is advised to take special care on the effect of ploughing on labor needed for weeding.
- (2) The economic performance of a tractor hiring service should be more attractive than the traditional system. It should be less labor intensive than oxen ploughing and it should reduce the time needed for weeding. The cost of hiring should be affordable for farmers and should be less than current prices for ploughing. Currently, in Amhara Region, farmers spend between ETB 564 (for 3 times ploughing) and ETB 1128 (for 6 times ploughing) with the average of ETB 940 (for 5 times ploughing). It is to be noted, however, that monetary payment for oxen hiring is not common in the study area.
- (3) Social-cultural factors. According to survey results, the majority of the farmers (66%) are willing to pay for the tractor service in cash. However, in the study area, farmers are not used to pay for oxen hiring service. The introduction of a tractor hiring service should, therefore, take into account that farmers are not always capable or willing to pay in cash in advance. Especially for less endowed farmers, collaboration with credit institutions that could provide input credit to pay for the THS might be one of the options to avoid this problem. It became clear from this study that oxen play a major role in the lives of farmers, both in economic and social sense. Oxen ploughing is a deeply rooted tradition in Ethiopia. Even though oxen ownership is likely to decrease in the near future, the social status associated with oxen ownership (and maybe even with oxen ploughing) will most likely remain a crucial factor to take into account while introducing a technology that does not need oxen. Some kind of social resistance, especially among older, less educated, and more traditional farmers, might be expected.
- (4) Political and institutional factors. Close collaboration with the government at all levels is a crucial condition for successful introduction. Hence, stakeholder meetings and involvement of district and *Kebele* extension centers is a key condition. Farmers also indicated that awareness creation is key issue, especially with a new technology such as a tractor. During focus group discussions, farmers mentioned that there should be a training platform where farmers can learn how to operate the tractor, and learn about its benefits. In line with this, facilitation of access to and use of credit for purchase of inputs (among which the tractor hiring service) will be likely to enhance adoption of the THS. Recently, the government is giving loans to common interest groups or cooperatives. The Agricultural Credit and Saving Institute (ACSI) could be another source of loan.
- (5) Awareness creation. The decision to use credit to pay for the tractor hiring service would be a very new idea to farmers. Although it is common in Amhara Region to use credit to purchase inputs (fertilizer, seed), none of the farmers in the study area currently uses credit to pay for oxen hiring service. Hence, this needs awareness creation. From the literature it is known that farmers who are less educated and less experienced with modern technologies, are often hesitant to serve as “guinea-pig” and hence working with more advanced farmers in this regard might be a proper way to introduce the technology to the area.



#### 4. Conclusions

From the results of the study, the following conclusions can be drawn.

- The socioeconomic characteristics of households like being model farmer, sex of households, age of the household, land size, oxen ownership, availability of female adult labor, and herbicide usage were the main factors that affect tractor hiring service (THS) in the study area.
- There were no taboos surrounding oxen that prevent the adoption of tractors.
- The main challenges of farmers associated with weeding are labor and herbicides shortage.
- Even though oxen ownership is likely to decrease in the near future, the social status associated with oxen ownership (and may be even with oxen ploughing) will most likely remain a crucial factor to take into account while introducing a technology that does not need oxen.
- Farmers are especially willing to use tractor hiring service if it is able to plough the land in dry conditions to use the rainy season for crop management activities.
- The condition for adoption of tractor services were the quality of tractor ploughing, the economic performance of a tractor hiring service (like affordable cost and reduced time and less labor use) should be more attractive than the traditional plough and close collaboration with the government at all levels is a crucial condition for successful introduction of the tractor services.
- The government or the private sector should set up agricultural machinery centers which can support in maintenance and rent out tractors to small scale farmers at subsidized rates.

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#### Competing interests

The authors declare no competing interest.

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