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Assessment of Agricultural Mechanization Utilization Status and Analysis of Productivity and Wage Employment at Siltie Zone, Central Ethiopia

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Abstract

There was no alternative solution except the utilization of farm machinery to enhance crop productivity. While in Ethiopia, the level of usage of agricultural machinery remains quite low and heavily relies on traditional power sources. Therefore, assessing, understanding the fundamental roots and their effect on agricultural productivity was crucial. Using data collected from a household survey of 240 farmers in four major wheat and maize producing districts of the Siltie zone. The inventory of farm machinery was also visited and assessed at the surveyed areas of investors, unions, and research centers. The farm mechanization index was used to evaluate the level of agricultural mechanization. While the level of productivity for each study area payment (rent) was determined as an inverse of the explicit factors involved in the production function (machine and labor). Results show that except for two investors, the utilization statuses of farm machinery were restricted only to tillage and harvesting operations for wheat, barley, and only tillage operations for maize crops. The overall productivity of wheat and maize yield in quintal per hectare at different farming practices was higher at mechanization farms (26.43, 28.39 qt/ha than (10.98, 17.34 qt/ha) non-mechanization farms, respectively. The average man-hour used for plowing and harvesting was higher at non-mechanized farm than mechanized farm. The average productivity level of (tractor) (0.709 kWhr/ha) was higher than human labor productivity (0.188 kWh/ha. Due to wage employment, manually operated farms used the highest man-hours to machinery-operated farms. It concluded that machinery-operated farms have a positive effect on the productivity of crops and labor with certain displacement costs. Thus, the Ethiopian government should control the illegal brokers, support and enhance the accessibility of appropriate agricultural machinery for all levels of farm size at reasonable prices for farmers through hiring or purchase.

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INTRODUCTION

According to Giller et al.'s (2022) [1] report, a global approach to the food system is essential to achieve global food and nutritional security. Agricultural farming is the primary source of employment for the population of 75% of Sub-Saharan Africa and 80% of Ethiopians involved either directly or indirectly [2], and that is mainly characterized by smallholder farms that depend on rain-fed agriculture [3]. 85% of Ethiopians are employed in agriculture, which also provides 90% of export earnings, over three-quarters of value-based exports, 50% of GDP, 90 % of rural employment, and other benefits [4–10]. Nevertheless, Sub-Saharan Africa was one of the regions with millions of people living under extreme poverty in the world [11].

Because farm power in SSA heavily relies on manpower sources [12]. Using fully or partially farm machinery, quality seed, and appropriate agronomic practices were some of the improvements of inputs for raising overall productivity and quality production at a minimum cost of production [13]. Different research findings [14–16] emphasized that farm machinery is area significant component for agricultural development, efficient utilization of resources, a factor for increasing the productivity and transformation of enhancing agricultural production of the rural communities at large [17]. According to Filani and Ejiko's (2018) [18] report, there was no alternative solution except the utilization of agricultural technologies (i.e., tractor and combine harvester) to enhance crop yield productivity and mainly applicable in the power-intensive agricultural operations and characterized by non-human sources of energy inputs to substitute manpower in the operations [19, 20]. It would empower farmers to cultivate additional land, reduce the need for manual labor, and increase the speed of tasks [21] and yield reduction, farmers' production cost, time, and post-harvest losses from 20%–5% [22]. Achievable level of labor and land productivity [23] farming profitability, environmental sustainability, and the standard of living for those involved in agricultural enterprises are all directly and significantly influenced by the quantity, suitability, and subsequent appropriate use of mechanized inputs in agriculture [24]. Though the utilization of agricultural machinery technologies is equally important in improving agricultural yields, like other biological technologies. Therefore, assessing the existing farming practices, understanding the fundamental roots and their effect on the productivity of labor, studying crops and wage employment was crucial.

OBJECTIVES

General Objective

- To assess existing farming practices, machine and human labor productivity, and the analysis of wage employment in the study areas.

Specific Objectives

- To assess the existing farming practices used by farmers in the surveyed areas
- To measure the machinery level, productivity of human labor and machinery (tractor) under wheat and maize production.
- To analyze the employment of wages to produce the study crops under existing farming practices

METHODOLOGY

Explanation of the Study Area

The study was carried out at major wheat and maize-producing weredas of Siltie zone, Central Ethiopia, and it was located 172 km from the capital of Addis Ababa and located at 70º48'35"N latitude, 38º09'25"S longitude, 2068 m.a.sl., 982 mm of precipitation, and 11.25°C temperature on average yearly. It has a total population of 1,250398 (612696 men & 637702 women) (CSA, 2007).

The remaining two surveyed kebeles, such as Achamo and Jaseyato kebeles, were not presented in the above legend due to the software could not describe these kebeles.

Methods of Data Collection and Sampling Procedure

The data were classified into two groups of mechanized and non-mechanized farms, to quantify existing farming practices. For this study, mechanization farming refers to farmers who use at least two or more agricultural machinery. On the other hand, non-mechanization farms, farmers do not use any farm machinery and generally carry out the activities by using animal and human power. Criteria for selection of surveyed areas based on agro-ecological, its capacity for producing the study crops, climatic conditions, soil type, and labor utility. Based on that, four potential wheat and maize producing weredas of the Siltie zone (i.e., Sankura, Mito, Misrak Silti, and Hulbareg) and from each three kebeles were chosen.

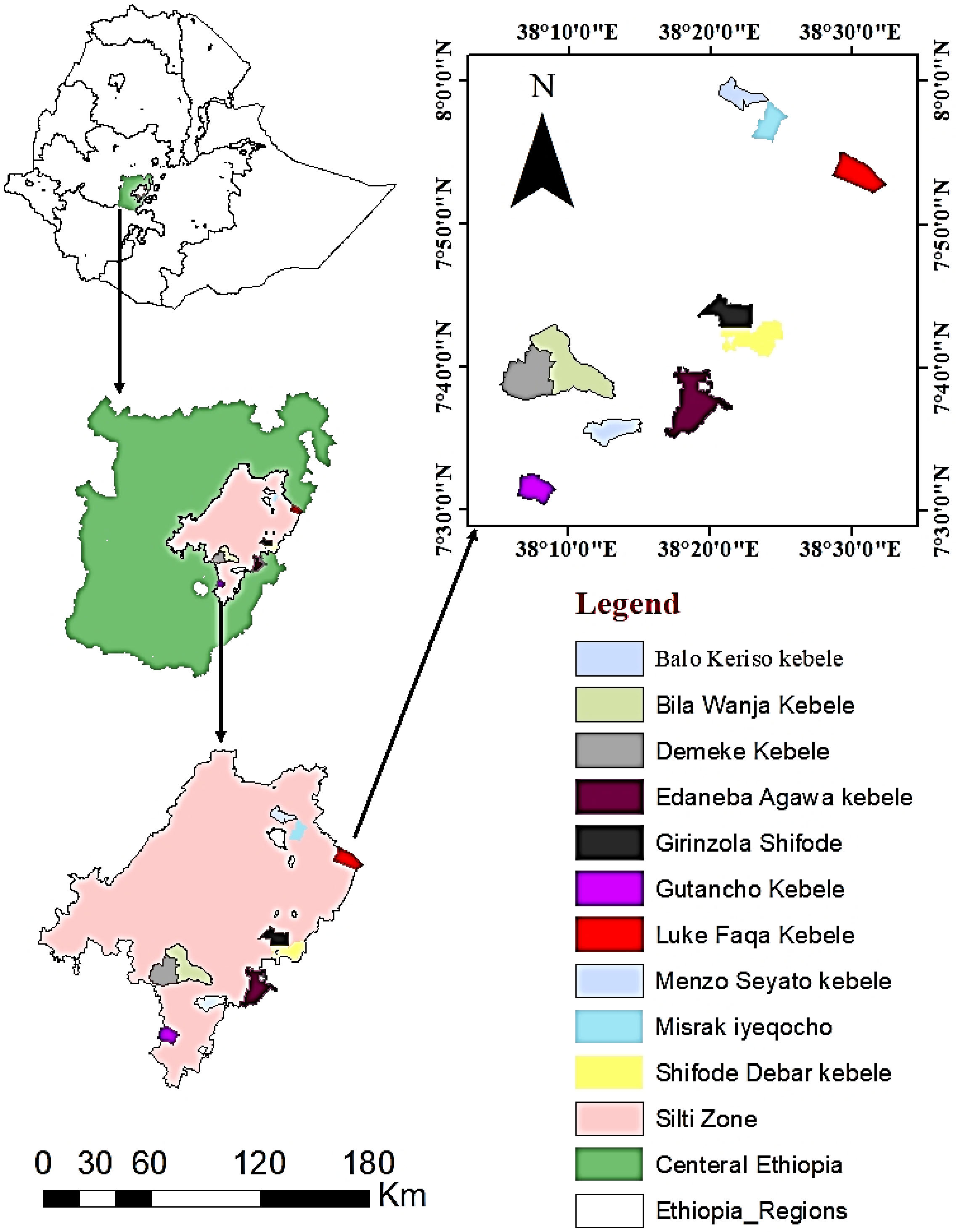

Figure 1. Map of the study areas.

Primary data were collected through questionnaires, semi-structured interviews, and direct observation by the researcher to ensure the data quality. The primary data were collected from a random sample of 240 farmers by the personal interview method. Secondary data were collected from various government institutions, published and unpublished sources. The questioner covered the general information of the selected farm payments, technical aspects concerning existing farm payments, institutional–organizational supervision techniques, the utilization of farm machinery (land preparation/tillage, planting, weeding, fertilizer and chemical application, harvesting, processing, and storage activities, and farm machinery maintenance. All the data collected from samples were related to the year of the 2021–2022 cropping season. The sample size was determined based on the simplified [25] formula. The target population of the current study was farmers of three kebeles of four weredas, one research center, and a union.

Sampling size was determined by

$$n = \frac{Z^2 pqN}{d^2(N-1)+Z^2 pq}, \quad (1)$$

where n = needed sample size, N = total number of households in the chosen kebeles (11540), P = probability of success, q = probability of failure, Z = Coefficient, and d marginal error (5 & 10 %). Using a margin of error of 5% the confidence level is 95%, P = 0.5, the probability of success, while the probability of failure is q = 0.5 as $Z_{0.25} = 1.65$.

Dimension of Machinery Index in the Study Areas

Level of Farm Machinery in the Surveyed Areas

The assessment of the grading level of existing farming practices was Hand tools (HT) or human labor (HL) = 1, Animal draft (AD) = 2, and tractorized (M) = 3. For the current study, the index of mechanization was limited to the power sources of (HL_1 and M_3). The level of farm machinery at the two available power sources was described as below. The level of farm machinery (HT1) was the average energy input of work provided solely by human power (labor) per hectare: it was indicated as defined by Nowacki (1974).

$$\text{HL} = 0.1 \times NH \times \frac{TH}{A}, \quad (2)$$

where LH = average energy input (work provided) per hectare by human labor, KWh/ha, NH = average number of labor employed, TH = average rated working time devoted to manual operation, 0.1 = theoretical average power of an average man working optimally, A = area of cultivated land (ha). A was determined for surveyed farmers' average farm payment by multiplying areas of cultivated land in hectares allocated to average surveyed farmers by the total number of surveyed farmers. TH was determined as a function of rate, energy consumption, and resting period for manual operations (Tillage operations). According to Caruthers and Rodriguez (1992), resting period (tR) was defined as follows:

$$\text{tR} = 60\left(1 - \frac{250}{P}\right), \quad (3)$$

where tR = required resting time for 8 hours effective working hours per day in minutes per hour of work; P = rate of power consumption in watts for various farming activities. Level of mechanization (M_3) represents the first level of mechanization, motorized machinery coexisting with the participation of operators (Nowacki, 1974). It indicates that

$$\text{LM} = 0.2 - NM - \frac{TM}{A}, \quad (4)$$

where LM = average energy input (work) per hectare by motorized machinery (Tractor), 0.2 = corrector coefficient of tractor-powered machinery, NM = rated working power of the tractor (KW), TM = Rated working time of the motorized energy source (Tractor), hr/ha, TM = 1/C, A = area worked in hectares by motorized machine (tractor).

$$\text{Effective field capacity C} = \frac{SWEf\ ha/hr}{10}, \quad (5)$$

where C = effective field capacity (ha/hr), W = width of cut of implements (m), EF = field efficiency (%), S = operating speed (m/s.).

Purpose of the Index of Farm Machinery

The measurement index (MI) represents the percentage of total work done by humans and machinery in the area, expressed using Equation (6). This index presents the measure of the assessment and status of the different levels of machinery practiced in the surveyed areas. Relative and different power sources are measured in the study areas. Compared to different power sources in the study areas, the machinery index was seen as a deviation of the actual amount of machinery operated for farm work from the normal values. Agricultural machinery index based on the use of manpower and mechanical energy inputs represent the total percentage of tractor and human labor, and it is calculated by using (Ramirez et al., 2007; Bello, 2012) equations.

$$\mathrm{MI} = \frac{\mathrm{EM}}{\mathrm{EM} + \mathrm{EH}} \times 100\ \%, \quad (6)$$

where EM = energy of machinery operated (tractor) (kwhr/ha), EH = energy of human labor operated (kwhr/ha). The implication of the EH parameter is determined based on the exact response of the surveyed farmers to the estimated resting period in minutes per hour of work on a manual farm operated.

Dimension of Machinery (Tractor) and Human Labor Productivity

The productivity of machine (Tractor) and human power could be determined based on the principle of production-specific inputs given the existing technology (tractor). The productivity of machinery (tractor), human labor, and total productivity were expressed by Ortiz-Canavate and Salvador (1980) [26], presented in the following equations.

$$\mathrm{AM} = \frac{1}{EM} \quad (7)$$

$$\mathrm{AH} = \frac{1}{EH} \quad (8)$$

$$\mathrm{AT} = \frac{1}{EM} + \frac{1}{EH}, \quad (9)$$

where: AM = productivity of machinery (tractor), it defined as the work carried out as a function of the tractor employed, AH = productivity of human labor (man-power), it defended as the work carried out as a function of human labor employed, AT = total productivity and it defined as the level of human labor productivity for each surveyed areas was determined as an inverse of the work outlay the explicit factors in production function (machine and human labor).

Data Analysis Methods

The current survey was analyzed by SPSS software. Descriptive (i.e., mean, frequency, percentage, and Std.) used to present an overall data, figures and tables were used for easy presentation of the results and it was also used an econometric model and independent sample test (test compare means of the two groups), multiple linear regression model (the degree of relationships among dependent and independent variables). ANOVA table is also used to analyze the significant contributing level of the independent variables in the prediction of the dependent variable agreement. The standard format of the linear regression model was described as below.

$Y = f(x1+ x2 +x3+ x4 +x5+ x6+ui\ldots\ldots\ldots)$.

The explicit function can be represented as:

$$Yi = \beta0 +\beta1x1i+\beta2x2i+\beta3x3i+\beta4x4i+\beta5x5i+\beta6x6i+ui, \tag{9}$$

where Y = amount of production of wheat/ maize crop in (qt/ha), X1 = farm size in (ha), X2 = number of human labor contributed in (ha), X3 = amount of fertilizer in (kg/ha), X4 = amount of chemicals using herbicide, fungicide, fungicide and insect side in (litters), X5 = amount of improved seed (kg/ha), X6 = type of farming practices, β0 = Intercept of the function and β1, β2, β3, β4, and β5 were the elasticity's of the respective inputs and ui was the residual effect.

Correlation Analysis

A simple correlation was made to determine the association of different independent variables by using Pearson's simple correlation.

RESULTS AND DISCUSSIONS

Socio-Economic Appearance of the Sampled Farmers

The current result indicates that a large portion, 113 (47.1%) of sampled farmers were found in the middle-aged 30 to 40 years (Table 1). It implies that crop production and animal husbandry were typically practiced among middle-aged individuals. The current result was comparable to different research findings [23, 27–28], which report that most of the average age of farmers to cultivate farms in the schemes was 31 to 40 years old. But it was dissimilar from the conclusion of Guo et al. (2015) [29], which reports crop producers in northern and southern Jiangsu have in the aged 50 to 60 years. Regarding the educational attainment, 85 (35.5%) had only completed basic school, and roughly 31.7% had never attended any formal schooling. 61(25.4 %) attended secondary education, and very few, 18 (7.5 %) attended tertiary education (high school and college). The observed data were lower than the national figure for adult literacy (36%), which implies that the farmers of the surveyed area were higher than in terms of educational level.

According to gender issues, 90.4% (217 farmers) were headed by males, while female respondents made up 9.6% (23 farmers). The observed data show that in the surveyed area, men are more involved in agricultural production and adoption of farm machinery than women. This finding was in line with the findings of Filani and Ejiko (2018) and Assefa et al.'s (2008) [18, 30] report that male respondents were more active than females in raising livestock and cultivating crops. Similarly, Ayele and Tamirat (2020) [31] concluded that most of the households were headed by males to produce cereal crops, which means it is a typical description of developing countries where male-headed households were dominant. Nonetheless, the current result was opposed to the finding of Food and Agriculture Organization (FAO) (2011) [32] who reports that in rural eastern Africa, the percentage of female-headed households was higher than male-headed to operate agricultural production due to migration of men away from rural areas to seek jobs elsewhere, widows, divorce, and other family disruptions [33].

Table 1. The basic socioeconomic features of the respondents.

Variables	Frequency	Percent
Age of respondents		
Less than 30	51	21.1

30–40	113	47.1
41–50	58	24.2
51– 60	15	6.3
Greater than 60	3	1.3
Educational status of the respondents		
No formal education (literacy)	76	31.7
Primary education	85	35.4
High school level	61	25.4
Higher education	18	7.5
Gender		
Female	23	9.6
Male	217	90.4

Existing Farming Practices and Year of Starting to Utilize Farm Machinery

The result shows that 40% of the households surveyed used mechanized farming and 20.8% of farmers used traditional farming methods. This may be due to their small farm size, high price of machinery from illegal brokers, and lack of road access and 39.2% of surveyed farmers use partial mechanization (tractor use only for the first rounds of plowing (Table 3). Generally, mechanical operations in the assessed areas were restricted to tillage and harvesting of specific crops (i.e., wheat and barley, and solely tillage for maize) crops except two investors. Manual labor was used for other tasks like planting, weeding, applying fertilizer, and harvesting maize. The fact that improved technology was not effectively applied in practice was a sign that systems were becoming older. This finding was supported by Olosunde et al. (2019); Ramya et al. (2016) [34, 35], which report that the only mechanical operations allowed were tillage operations, but other activities, including harvesting, planting, weeding, applying fertilizer, and herbicides were carried out manually. Utilization of farm machinery (plowing and harvesting) in the study areas was started in the early 2005s. The majority of the respondents, 93 (48.9%), began in the year 2011–2013. Since 2005–2007 and 2008–2010 the overall year of starting agricultural machinery usage was higher in Mito than in other study weredas, but since 2011–2013, the demand for agricultural machinery has been higher in Hulbareg than the rest surveyed weredas (Figure 2).

Table 2. Response of farmers according to existing farming practices used farm machinery.

Variables	**Frequency**	**Percentage (%)**
Types of farm practices used		
Non mechanized	50	20.8
Partial mechanized	94	39.2
Mechanized	96	40.0
Year of starting farm machinery		
2005–2007	27	14.3
2008–2010	70	36.8
2011–2013	93	48.9

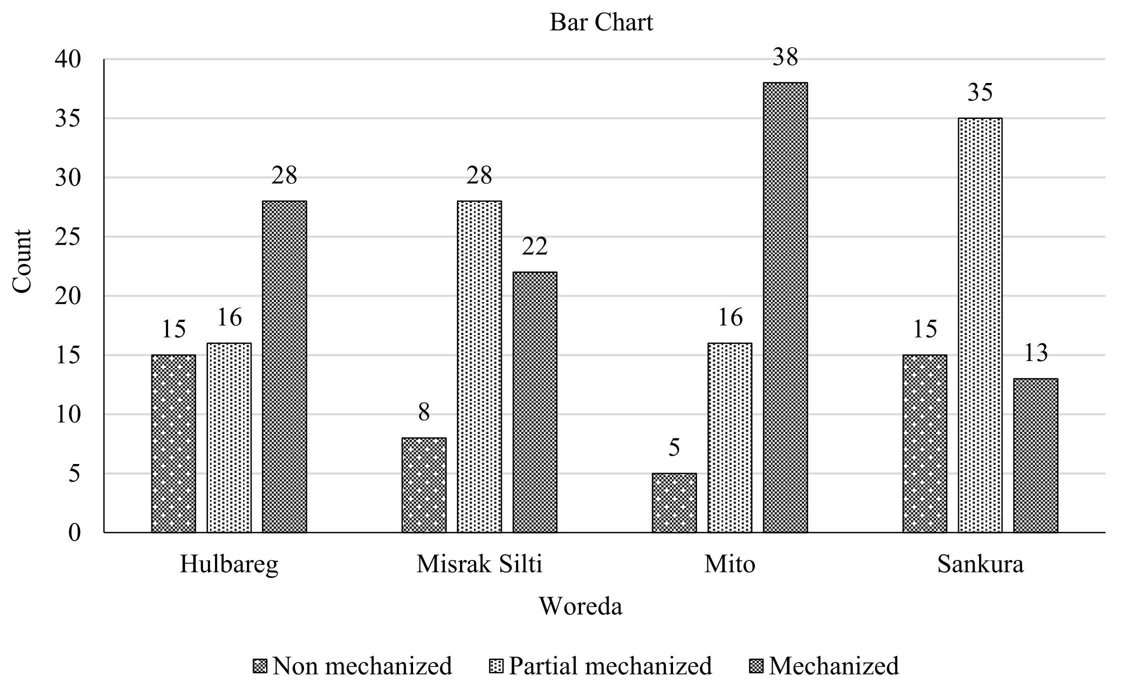

Figure 2. Distribution of existing farming practices used by farmers.

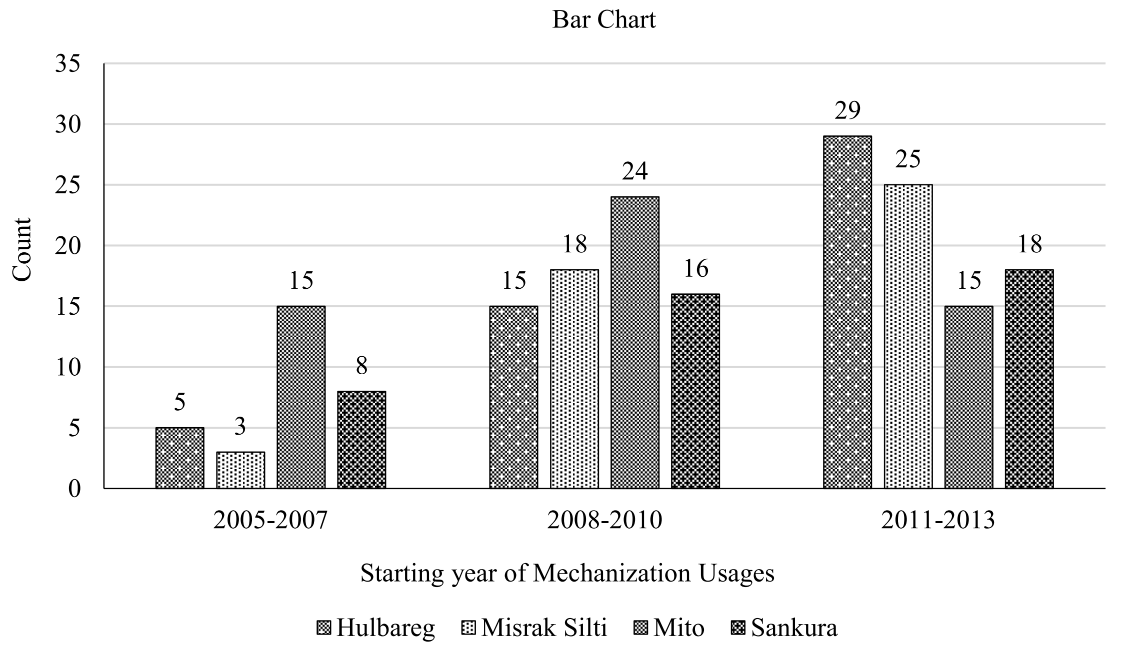

Figure 3. Year of starting farm mechanization used within the study areas.

The Effect of Existing Farming Practices on the Productivity of Wheat and Maize Crops

Result shows that the mean wheat yield was greater at mechanized (26.43 qt/ha) than partially mechanized (22.45) and non-mechanized operated farms (18.14) with Std. of (10.202, 11.243, and 9.842), respectively (Table 4). The mean maize yield was higher at the partial mechanized (26.38) than the non-mechanized farm (18.45 qt/ha), with the Std. of (15.538 and 11.037), respectively. Generally, the current findings suggest that tractors and combine harvesters operated farms have more productive than manually operated farms for both crops. This result was confirmed by Ramya et al.

(2016) [35] report, which concluded that tractor-operated farms produced more wheat yield than manually operated farms. This result was also in agreement with Government of Pakistan (GOP)'s (2010) [36] reports that farm mechanization helped in increasing the cultivated area of major crops (i.e., wheat, rice, and maize to 0.4%, 10.4% and 27.3%, respectively. Similarly, Singh and Singh (1972) [37] supported that tractorized farms gave higher yields of (wheat, paddy, rice, and sugarcane) than manually operated farms. Ramya et al. (2016) [35] report that in India, by using improved agricultural inputs, farm production and productivity have increased 3–4 fold.

Table 3. Mean production of wheat and maize crops at different farming practices.

Mean Yield of the Surveyed Crops qt/ha	Type of Farm Practices Used in Surveyed Households	Mean	Std.	Sig.
Wheat	NMF	18.14	9.842	.000
	MF	26.43	10.202	.000
	PMF	22.45	11.243	.061
Maize	NMF	18.45	11.037	.002
	PMF	26.38	15.538	.001

Note: NMF = Non-mechanized farm, MF = Mechanized farm, PMF = Partial mechanized farm.

Index of Farm Machinery

In the current study, mechanical operations were restricted only to tillage (plowing) and harvesting operations for wheat crops. Other operations planting, weeding, fertilizer and chemical applications, and harvesting of other crops, were manually done. These were due to the lack of standardization and availability of farm machinery inputs to serve the whole scale of production. It implies that low productivity of labor and machinery (tractor) power, and the use of old tractors with related continuous breakdown during operations. The work out lay (M = machinery (Tractor), and hand tool or HL = human labor) determined for various farm payments for the power sources investigated. The timeliness in operation for tractor power was determined by considering the width of cut (W) of the implement, operating speed, and machinery efficiency (tractor). While for human labor (HL) was determined by giving consideration to the total resting period per 8 hours of work as expressed in Equation (3). The index of farm machinery (tractor) for each district of the farm was determined using Equation (6) and the result was represented in Table 5. It shows that as the index of mechanization increases, energy input per land area in hectares by human labor work was greater than the energy input of machinery. This indicates that great work capacity and more time of utilization of human labor were needed for the same area. The result shows that the mean productivity of machinery (tractor) (0.709) for plowing was higher than human labor productivity (0.188) (Table 4). This suggests that the productivity of the tractor was more productive than humans when it came to production. The highest productivity of machinery (tractor), 86.8% of the total farm productivity, was at Hulbareg wereda. But the least contribution was made in Misrak Silti (74.9%). The significant difference in energy from human and mechanical operation within weredas may be due to the variation of resting time of human labor, power of the machinery, and soil type, respectively. Based on energy production (Equations 7–9), the mean energy produced from machinery (tractor) (5.59) was lower than human labor (26.5 kWhr/ha) operated farm (Table 6). Energy from human-operated parameters was determined based on surveyed farmers' responses on the estimated resting period in minutes per hour of work on each manually operated farm (plowing). This result was supported by [34, 23] conclusions that the average productivity level of machinery power involvement was significantly high as compared to human labor productivity.

Table 4. Mean productivity of machinery and human labor, total productivity, and % contributed by machine productivity in total per unit areas of cultivated land at surveyed areas.

Study Areas	Productivity of Machine (Tractor) AM (ha kwhr.) = 1/Em	Productivity of Human Labor AH (ha kwhr.) = 1/AH	Total Productivity at (ha kwhr.) = 1/EM + 1/EH	% Contribution of Machine Productivity in Total = AM × AT × 100
Hulbareg	0.125	0.019	0.144	86.8
Misrak silti	0.167	0.056	0.223	74.9
Mito	0.25	0.063	0.313	79.9

Sankura	0.167	0.05	0.217	77
Average	0.709	0.188	0.897	79.65

Note: Am = Amount of machinery productivity (tractor), AH = Amount of human labor productivity, EM = Energy from machinery operated, EH = Energy from human labor operated, AT = Total productivity.

The Effect of Existing Farming Practices on Employment of Human Labor/Wage

Result shows the average human labor, rated working time devoted (man-hour) used for plowing and plowing frequency for wheat and maize crops were observed higher at non-mechanized farm (16 labor, 7.4hr) × (4 plowing frequency) than in a fully tractor-operated farm (2 labor, 54" (0.9 hr.) × (1.3 plowing frequency), respectively. This implies that the mean value of manually and tractor-operated farms for wheat and maize crops takes 29.6 man-hours (3.7 man-days) and 1.8 man-hours (0.225 man-days) for one round of plowing per hectare (Table 6).

Table 5. The effect of farming practices on the employment of wage earners.

Variables	Farming Practices	Mean	Std.	Sig.
No. of labor used/ha)				
For plowing	NMF	16.00	.000	.000
	FTOF	2.00	.000	.000
For harvesting and threshing of wheat	NMF	13.64	5.223	.000
	MF	6.48	1.795	.000
RWTD (hr./ha)				
To plow	NMF	7.380	.49031	.000
	FTOF	54.05"	13.454"	.000
To harvest and thresh	NMF	9.0714	.26227	.000
	MF	37.63"	13.236"	.000
Plowing frequency	NMF	3.7000	.58029	.000
	FTOF	1.2813	.45197	.000
Manual maize harvesting	NM	19.8723	10.95964	–
Amount of income from off-farm	NMF	4113.9	10436.7	.009
	PMF	3410.2	10285.6	.000
	MF	10826.5	14814.1	.000

Note: NMF = Non-mechanized farm, MF = Mechanized farm, RWTD = Rated working time devoted, hr/ha = hour per hectare, Man-day Number of labor used, FTOF = Fully tractor operated farm.

Table 6. The average energy produced from mechanical and human labor operation (kWhr./ha) within weredas.

Study Areas	MI (%) = Em/Em + Eh × 100%	AEM kWh/ha = 0.2 – NM – TM/A	AEH kWh./ha = 0.1 × NH × TH/A
Hulbareg	13.19	8	52.63
Misrak silti	24.89	5.9	17.8
Mito	20.20	4	15.8
Sankura	22.77	5.9	20
Average	18.33	5.95	26.5

Note: MI = mechanization index, EM = Average energy from machinery operated, AEH = Average energy from human labor operated, NM = Rated working power of the machinery, TM = rated working time of tractor, average number of human labor employed, TH = average working time to manual operation, A = area cultivated.

Similarly, the average human labor and rated working time devoted (man-hour) used for harvesting and threshing for wheat crops were observed to be higher at a non-mechanized farm (13.64 laborman-hours, 9.07 hr.) than in a mechanized farm (6.48 labor, 37.6" (0.61 hr.) with the Std. of (5.223, 1.795) per hectare, respectively. This implies that the mean value of manually and mechanically harvesting and threshing of wheat crop takes 123.7 man-hours (approximately 15 man-days) and 3.9 man-hours (0.49 man-days) per hectare. The mean value of human labor used for manual maize harvesting and threshing, and rated working time devoted was recorded (19.8723) man-days for 9.07 hours per hectare.

According to this finding, manual maize harvest and thresh normally requires 178.87 to 279.5 man-hours or around 22 to 35 man-days with a Std. of (10.95964) per hectare. The current findings generally indicate that manually operated farms utilize more man-hours than mechanical farms. Mechanized farms generated more income from off-farm sources (10826.5 ETB) than a non-mechanized farm (4113.9 ETB) Std. (14814.1, 10436.7), respectively. Furthermore, post-harvest loss and grain yield quality are impacted by manual crop harvesting. The current result was greater than that from the finding of Food and Agriculture Organization (FAO) (1994) [38], which reports that a manual maize harvest typically takes between 120 and 200 man-hours or 20 to 25 man-days per hectare.

Effect of Different Variables on the Productivity of Study Crops

Result shows that agricultural inputs, type of farming practices, and land size were positively and negatively significant effects and conducive to improving wheat and maize production. The descriptive power of the model to produce wheat shows a coefficient of multiple determinations (R^2 = 58.9%). It specifies that 58.9% of the variation of wheat yield was jointly explained by the explanatory variables (Table 7). Similarly, the explanatory power of the model for maize production shows a coefficient of multiple determinations (R^2 = 60.7%). It specifies that 60.7% of the variation of maize yield was jointly explained by the explanatory variables. This result is supported by Guo et al. (2015) [29], which determined that improved technologies and their interactions show significant effects on agricultural production (Table 8).

Table 7. Factors that influence the respondents of wheat yield.

Model	Unstandardized Coefficient		Standardized Coefficient	T	Sig.
	B	*Std. Error*	*Beta*		
Type of farm practices used by farmers	4.717	1.384	.371	3.409	.001
Land size in ha	.540	1.443	.022	.375	.708
Urea fertilizer kg/ha	–.011	.031	–.036	–.347	.729
NPS fertilizer kg/ha	.059	.038	.178	1.530	.128
Improved seed kg/ha	.143	.026	.513	5.510	.000
Herbicide chemicals lit/ha	2.805	2.486	.089	1.128	.261
Fungicide chemicals lit/ha	–.596	2.364	–.016	–.252	.801
Number of labor contributions	.134	.338	.019	.396	.692

Note: a. Dependent Variable: wheat yield qt/ha. R^2 = 58.9%.

Table 8. Factors that influence the respondent's maize yield.

Model	Unstandardized Coefficient		Standardized Coefficient	T-Value	Sig.
	B	*Std. Error*	*Beta*		
Urea fertilizer used in kg/ha	.014	.035	.042	.398	.691
NPS fertilizer kg/ha	.096	.035	.275	2.711	.007
Improved seed kg/ha	.487	.128	.303	3.820	.000
Insecticide chemicals lit/ha	4.858	2.174	.119	2.234	.027
Type of farm practices used by farmers	4.830	1.314	.221	3.676	.000
Land size	–5.568	1.886	–.147	–2.953	.004
Number of labor contributions	.225	.381	.028	.591	.556

Note: a. Dependent Variable: maize yield qt/ha. R^2 = 60.7.

Rental Prices for Different Variables in the Study Areas

Under the two groups (mechanized and non-mechanized farms) of the examined areas, the mean and comparison rental prices of wage/day, labor with oxen/day, tractor/ha, and combine harvester /quintal) were presented in (Figure 4 and Table 9). The findings show that the average rental prices in Ethiopian birr were as follows: labor with paired oxen/day (338.78) Std. 133.022, tractor/ha (3286.15) Std. 304.935, combine harvester/quintal (148.55) Std. 35.563 and wage/day (151.78) Std. 52.232, respectively. Hiring cost variation of tractor and combine harvester in the surveyed areas depended on illegal brokers, different land history (Fallow or land on production), soil types (clay, loam, clay-loam, and sandy), amount of yields, location, size, and slope of the farm. Consequently, farmers' decisions on whether it was cost-effective to engage in these services depend on those costs. This result is confirmed by Ethiopia Strategy Support Program (ESSP)'s (2017) [39] reports the cost of using a combination harvester based on soil type, yield amount, temperature, location, and slope of the farm.

Table 9. Mean rental prices of different variables/ETB.

Variables	Minimum	Maximum	Mean	Std. Deviation
Wage (human labor)/day	70	450	151.78	52.232
Labor with paired oxen/day	200	800	338.78	133.022
Tractor per hectare	2700	3900	3286.15	304.935
Combiner per quintal	80	300	148.55	35.563

Major Constraints and Challenges That Hindered the Utilization of Farm Machinery in the Surveyed Areas

Result shows that high prices due to illegal brokers, small plot size, lack of road access to enter farm machinery, and low availability of skilled man-power as technical service providers to maintain the old machinery were also the key constraints in promoting mechanical operation in the study area. Even though the Melik farmers' union has some machinery, like (Tractor and combine harvester), additional accessibility of machinery for all land sizes, types, and service centers was essential in the study areas to improve agricultural productivity and timely operation by reducing drudgery (Table 10).

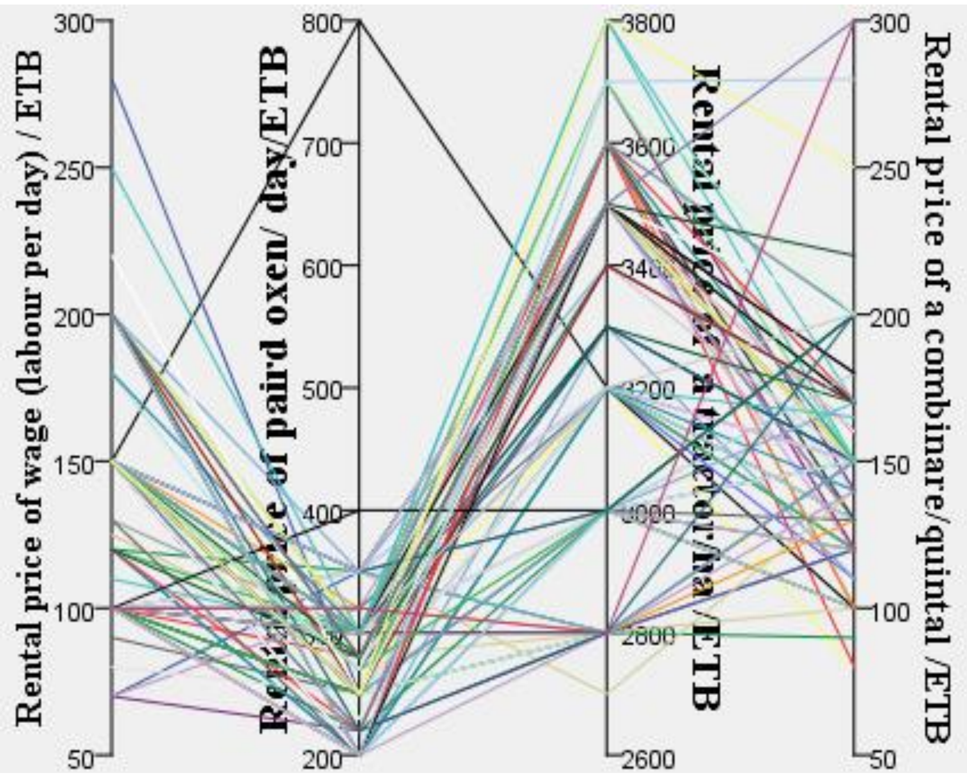

Figure 4. Rental prices comparison.

Table 10. Response of farmers according to that hindered the utilization of farm machinery.

Problems	Frequency	Percentage
High price due to illegal brokers	89	37.1
No road access	41	17.1
Small land size	54	22.5
Lack of information during the entry of farm machinery	14	5.8
Unavailability of machinery in time /Late coming/	3	1.3
Old models, insufficiency of farm machinery	5	2.1
Lack of maintenance service, income to rent farm machinery	6	2.5
High price of fuel for the power plough	1	.4
There is no problem using farm machinery	27	11.2

Correlation Analysis

Considering to correlation analysis of agricultural input variables (i.e., NPS and urea fertilizer, improved seed, chemicals (herbicide, fungicide, and insecticide), number of labor contribution, land size and type of farming practices employed; most of the variables were positively significantly correlated at 0.01 confidence level each other but number of labor contributed was positively significant correlated with area of cultivated land and fungicide chemical at 0.05 confidence level (r = .135* and r = .142*), respectively (11).

Table 11. Correlation analysis of different variables that influence the yield of wheat and maize crops.

		ACL	UF	NPSF	IS	HC	FC	IC	NLC
ACL									
UF		.468**							
NPSF		.457**	.877**						
IS		.505**	.766**	.763**					
HC		.460**	.490**	.527**	.494**				
FC		.437**	.491**	.454**	.489**	.615**			
IC		.345**	.482**	.396**	.356**	.436**	.572**		
NLC		.135*	.030	.004	.064	.077	.142*	.031	

Note: ACL = Area of cultivated land, UF = Urea fertilizer, NPSF = NPS fertilizer, IS = Improved seed, HC = Herbicide chemical, FC = Fungicide chemical, IC = Insecticide chemical, NLC = Number of labor contributions. **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

CONCLUSIONS AND RECOMMENDATIONS

The current result shows that except for two investors, mechanical operations as a whole were constrained only to tillage and harvestings for some crops (i.e., wheat, barley, and only tillage operation for maize). Other farm operations (planting, weeding, fertilizer and chemical application, harvesting, and threshing of maize and other crops were manually done. Based on the level of mechanization and measurement of productivity, human labor was less productive than machine, but the amount of income from non-farms was higher than at a mechanized farm as compared to a non-mechanized farm. As the index of mechanization increases, the energy input per land area in hectares by human labor work was greater than the energy input of machinery. This indicates that great work capacity and more time of the utilization of human labor were needed for the same area. Agricultural mechanization was effectively encouraged for crop production improvement by decreasing the number of human laborers and supporting the process of agricultural modernization.

The utilization status of improved agricultural technologies (i.e., tractor, combine harvester, seeds, and chemicals) trend has become widely accepted and of interest due to their improved efficiency and cost effectiveness. The wage employment of the current result implies that manually operating farming systems have the highest used man-hours (wage employment) than mechanical operating farms. Generally, farmers' experience in the study areas shows that mechanization has an overall positive effect on the productivity of the study crops with certain costs, especially a little complementing of human labor.

Major constraints and challenges that hindered to utilization of farm machinery were 1st high prices due to illegal brokers, 2nd small plot size, and 3rd lack of road access to enter farm machinery. Successful implementation of agricultural machinery at all farm levels requires an effort by policy makers, government, and non-government organizations, and extension workers to train farmers on the newly introduced machinery, modify, expand, and adopt the existing ones.

Therefore, the government should promote and encourage appropriate farm machinery like other improved agricultural inputs at a reasonably priced for existing farmers. Boost and support local enterprises, farmers' cooperative, private investors, and unions to offer farm machinery hiring service, and implement tax-free import polices for farm machinery were some of the opportunities that demand attention. Policy makers should design strategies to absorb the wages that were expected to displace labor surplus from agricultural activities to other social life to improve additional incomes. On the other hand, inappropriate and overuse of farm machinery for land preparation (frequent tillage) may affect biodiversity and biological processes, damage, and finally affect climate change.

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Data Availability
The data are available upon request from the corresponding author.

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