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RESEARCH ARTICLE

Evaluation of Current Farm Machinery Utilization and Farm Productivity in Hadiya Zone, Central Ethiopia

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ABSTRACT

Using farm machinery to improve farming has several benefits, such as labor saving, the higher labor efficiency, and the more precise and timely operations. This study aimed to identify farmland eligible for mechanization in the Hadiya zone, central Ethiopia through formal interviews and key informant interviews in selected districts. With data from 2019 to 2023, the study used both quantitative and qualitative approaches to examine productivity and machinery usage status. According to the data, 16.98% and 20.81% of farmland was mechanized in 2019 and 2023, respectively. The productivity of cereal crops increased when they were mechanized as opposed to not. According to the mechanization index measurement result, Shashogo had the highest mechanical power (30.8%), and Misrak Badawacho had the lowest (11.88%); this showed that human work requires a large energy input per hectare for Misrak Badawacho district. The article estimated differences in productivity between mechanized and non-mechanized plots for different crops. They amounted to 34.80%, 47.85%, 29.41%, and 46.58% for respective barley, teff, wheat, and maize. There were variations of horsepower per hectare among districts in the Hadiya zone due to landscape orientation and access to the existing resources in Lemo and Misrak Badawacho districts horsepower/hectare was 0.15 and 0.20, respectively. The result showed that out of the total cultivable land in the Hadiya zone, about 146,551 ha of land is eligible for mechanization in terms of both farm production and machinery uti-

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lization. The Central regional government is advised to support the appropriate use of agricultural equipment that is affordable for subsistence farmers through rental or credit terms; to apply the cluster farming system for small landholding in an appropriate manner for each district in the Hadiya zone; and to use farm machinery, as the study found a significant relationship between farm machinery and farm productivity: the low farm productivity results from low machinery utilization, which is caused by the government, lack of focus on farmer support, environmental sustainability, and farm production declines despite machinery utilization in central Ethiopia, Hadiya zone, and to use farm machinery, as the study found a significant relationship between farm machinery and farm productivity.
Keywords: Machinery Utilization; Farm Productivity; Farm Machinery; Mechanized Farm

1. Introduction

Farm machinery is an essential component of agricultural modernization and serves as a vital tool for promoting agricultural mechanization [1]. The utilization of manual tools, equipment, and machinery for farming operations regardless of levels of agricultural output is the broad definition of mechanization in agriculture [2]. A significant number of studies have emphasized that mechanization results in more effective resource utilization and enhanced factor output because of the benefits of more effective precision, efficient operation, reduced drudgery, and manpower savings [3]. Implementing farm machinery can have several beneficial consequences for rural development, particularly for smallholder agriculture [4].

Farmers, whether in industrialized or developing nations, mechanize their operations when the production of crops is more significantly impacted by mechanical sources of energy than by biological sources, human work, or animal labor [5]. Agricultural production in sub-Saharan Africa (SSA) has, in recent times, remained lower than the rest of the world. This is frequently ascribed to features of Africa, such as the environment, the soil, the labor, and illness of the animals [6]. Farmers are unable to depend only on hand-tool technology to support their livelihood in agriculture because people are a rather inefficient source of power, producing just approximately 0.01 horsepower of continuous crop production [7]. A study conducted by Yigezu Wendimu [8] claimed that the use of agricultural technology has expanded globally and is essential to both feed a fast-expanding population and promote industrialization. Sustainable agricultural mechanization is essential to sub-Saharan Africa's agricultural sector's continued growth [9].

To reduce poverty, promote environmental sustainability, and accelerate economic development, agriculture had collaborated with other economic sectors [8], to rise production from traditional agricultural systems to mechanical systems, it is usually necessary to update and improve infrastructure and introduce new technologies within the proper mechanization strategy [9]. It is believed that mechanization in developing nations could have a comparable impact as agricultural technology did in the developed world in raising living standards [10]. Less than 1% of Ethiopia's agricultural plots are plowed by tractors due to the limited uptake of agricultural mechanization [11]. The agricultural sector played a critical part in the recent developments. Despite several efforts made by different actors to reduce the global hunger problem, food insecurity and undernutrition are still major issues in many countries including Ethiopia [12].

The goal of Agenda 2063 for Africa is to further modernize the continent's agricultural sector and the best approach to maintain higher food production is to employ mechanical technology, which saves labor and directly improves yields [13]. Studies on economic development have concentrated on the value of agricultural mechanization in tackling the underlying barriers to the overall eradication of poverty and the enhancement of smallholder farmers' productivity [14].

Although increased agricultural technology has aided in the development of high-quality agriculture, agriculture that is severely damaged by unfavorable environmental circumstances must also transition to a green, sustainable form of agriculture [15]. In sub-Saharan Africa, almost 70% of farms are in rural areas, they only produced 25% of their potential yields [16].

Ethiopian farming is essential to the country's economic development as well as to the daily lives of its people. Around 820 million people globally face hunger every day, and more than two billion people lack important micronutrients, which influence their well-being as well as their lifespan [17]. The important role that agriculture plays economically is shown by the GDP's considerable share of agricultural production. The services and agricultural industries have been the main propellers of Ethiopia's economy's expansion in recent years. The industry sector's position has improved recently, nevertheless, the service sector generated about 50% of the growth overall, compared to the industry sector's contribution of roughly 39% in 2015–16. The high cost of public investment has made inflation more prevalent [18].

Most farmers in Ethiopia have continued to use traditional farming techniques. The low production of the agriculture industry is a result of this. Farmers are suffering because of the outdated and ineffective technology of land tilling practices in the case of soil tillage [19]. The majority of studies have shown a positive correlation between credit utilization and agricultural profitability. Farmers who use credit to purchase agricultural machinery and equipment increase farming productivity [10]. To increase food production, resource-friendly techniques are required, which will require the development of new farming technology [11]. However, poor access to finance and subsidies exists in the Hadiya Zone.

Agriculture is the backbone of the Ethiopian economy, playing a significant role in GDP, international export markets, rural employment, and raw materials for industry. However, low productivity, low agricultural machinery utilization, and small-holding subsistence farming are the major problems of agricultural mechanization. Low mechanical power usage and low cereal crop yield in zonal districts are also indicators of the Hadiya Zone. In the instance of soil tillage, farmers are suffering as a result of outmoded and ineffective land-tilling technologies [20]. Despite the fact that writers have undertaken studies on agricultural mechanization, improving animal-drawn tools, and productivity in Ethiopia [20–24]. Their studies did not show in depth about the agricultural productivity and used status of cereal crops.

About 10% of Earth's surface area, or 14.2 million km^2, are agricultural lands worldwide. Asia makes up 37.2% of the world's arable landmass on a continental scale, with Africa coming in second (19.8%), North and Central America (15.1%) third, Europe (13.8%) fourth, South America (10.5%) fifth, Australia and Oceania (3.5%) sixth. Although agricultural systems constitute a key component of the world's food security, several environmental problems, including land degradation and anthropogenic climate change, are currently endangering their productivity. Nonetheless, there is currently a lack of appropriate knowledge regarding the global spatial impact of land degradation processes on arable lands, which can be regarded as a significant part of global agricultural systems [25].

Africa had around 1,162 million hectares of arable land in 2021, which corresponded to nearly 40 percent of the continent's total land area. Women's labor contributions in African agriculture are often quoted between 60 and 80%. Based on individual disaggregated data at the plot level from nationally representative household surveys, the average female labor share in crop production is estimated at 40 % [26]. In 2019/ 2020, the CSAE estimated that 14.6 million hectares of farmland area were cultivated, of which grain crops accounted for 88.3% of cultivated land and cereal crops alone shared 71.9% of the total cultivated land. Ethiopia has a total area of approximately 113 million hectares and more than 38 million hectares of arable land (34.2%) [26].

The wheat belt zone in the central Ethiopian region, Hadiya Zone, and its accessible location make it a particularly productive area. Achieving food security is a struggle for the majority of farmers. The study focuses on how agricultural machinery affects the productivity of farmland for cereal crops, Ethiopia's development, and the government's commitment to enhancing the agricultural sector for the advancement of the economy of the country.

1.1. Objectives of the Study

- To determine farm availability and machinery utilization in five years.
- To evaluate non-mechanized and mechanized farm productivity.

- To determine the mechanization index in each zonal district.

2. Literature Review

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. Many proven technologies and planting improvement practices have the promise to boost agricultural production and reduce poverty in developing countries [27]. The majority of the world's food is produced by smallholder farmers, who may need to boost output by up to 100% by 2050 to feed the expanding population. Because of the need to accomplish this while protecting the environment, sustainable agricultural mechanization is essential to the process [28]. One of the factors that have the greatest impact on the increase of agricultural food productivity is the mechanization of agricultural work, according to the Operational Guide of the Program of Innovation, Research, Technological Development, and Education. Globally, mechanization has been one of the key components of high agricultural growth and therefore high food security. Agricultural technology played a part in lifting the living standards of the developed world and it is assumed that the mechanization of the developing world could deliver a similar outcome [10].

The underdevelopment of agricultural mechanization in Ethiopia is partly explained by the limited support and focus imparted to the sector. Studies showed that in many developing countries, human muscle provides up to 80% of farm power [29]. According to Olosunde, Onwe and Sunday [30], the globe has realized that using farm machinery is necessary to meet the food needs of the fast-expanding population and industrialization. The growth rate of major cereal yields (wheat, rice, and corn) is declining. Increasing food production requires resource-friendly methods, and this will require the development of new mechanization technology [31].

Smallholder farmers in developing nations account for a large portion of the world's undernourished and food-insecure population. In Africa in particular, this is accurate. Food systems and smallholder agriculture must become better aware of nutrition. It is well known that many African farm households consume a sizable portion of their produce [32]. Although Ethiopian agriculture has shown remarkably resilient over the years, it is currently failing more and more. Despite governmental efforts, there are still a great deal of people living in poverty and food insecurity, with an estimated 25 million people just surviving [33].

Grain output is raised by roughly 1.19% when equipment input rises by 10% a positive land channel of structure effect. On the other hand, because of the negative effects of fertilizer reduction, a 10% increase in the input of agricultural machinery has resulted in an approximately 2.20% decrease in grain output. Grain output is increased by machinery capacity and machinery structure, the primary goals of developing nations are always agricultural modernization and food security. This study has examined the impact of agricultural machinery on grain output, focusing on the capacity structure effect and the influence of subsidy policy[34].

Agricultural extension services are crucial in bridging the gap between research and real farming to boost farm production and sustainability on a global scale. In identified sub-Saharan African nations, the proportion of rural families with access to tractors is extremely low [35]. Farm mechanization has the potential to improve labor productivity and lessen the physical effort involved in farming on the millions of smallholder farms around the world, hence fostering socioeconomic growth in the Global South, especially in Africa [36]. Today's agriculture relies heavily on machinery. However, the pace at which agricultural machinery is used in Kenya and other African countries is still quite low. It is essential to comprehend the underlying reasons and how they affect agricultural productivity [37]. To improve the land productivity of grain production, various advanced technology elements are introduced into the process of grain production in the form of outsourcing services [38].

3. Methodology

3.1. Description of Study Area

The present investigation is conducted in the Hadiya Zone's central region of Ethiopia. Hosanna serves as the capital of Hadiya Zone, which is situated 232 kilometers southwest of Addis Abeba, the Ethiopian capital. With 1,797,395 million inhabitants and 11 (districts) before 2010/ 11 E.C, the Hadiya Zone includes Hosanna town. It is located 7°3′19″ N to 7°55′11″ N latitude and 37°23′14″ to 38°04′25″ E longitude (**Figure 1**). It is bordered on the west by the Dawuro and Kambata zones, on the east by the Halaba and Oromia regions, and on the north and south by the Gurage and Silte zones. The Hadiya Zone had a wide range of climates which includes highland, lowland, and midland. Its elevation is between 1200 and 2950 meters above sea level, and its typical temperature is between 18 °C and 25 °C. The average annual rainfall is 2371 mm. The main economic activity in the study zone is agriculture, with around 85% of the population involved in mixed farming (i.e., crop and animal production), based on the Hadiya Zone Finance and Economic Development Bureau. The soil type that is ideal for farming and agricultural practice is primarily subsistence; with the average farm size of the household being less than 1.2 hectares, Hadiya zone has 294 km of all-weather roads and 350 km of dry-weather roads, for an average road density of 169 km per 1000 square kilometers.

3.2. Design of the Study

This study employed a design to ascertain the amount of agricultural machinery used and how this impacts farm output in Hadiya Zone, central Ethiopia. The Agricultural Office, the central Ethiopia Region, and the Hadiya Zonal districts also contributed information. The following factors were taken into consideration when selecting the enumerators: work experience in agricultural institutions within the province of interest; research experience in the province of interest; familiarity with agricultural production and policies within the province of interest; and understanding of the links and relationships between the study area and extension. Using a stratified sample technique, mechanized and non-mechanized farmland, as well as cereal crop productivity per hectare, were chosen at the time of the study from Hadiya Zone, districts, and stakeholders.

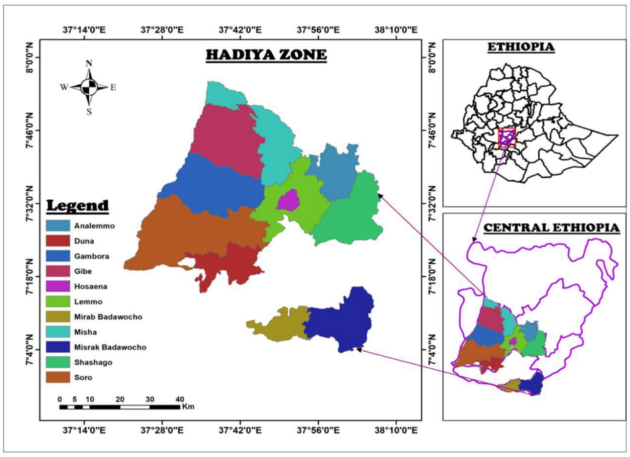

Figure 1. The Hadiya Zone and district map.

3.3. Data Collection Methods

The study used data collected through group discussion, personal interviews of 23 stakeholders, and cereal crop productivity and farm machinery data located in the central Ethiopia region, Hadiya zone, and Zonal Districts. The major data was obtained through field interaction with stakeholders depending on circumstances, focus group discussions and key informant interview data are primarily gathered through agricultural development offices and stakeholders in the study area. Respondents in the study included (3) agricultural mechanization leaders from the central Ethiopia region, (4) Hadiya Zone mechanization department and agricultural extension leaders, and (1) mechanization leaders and agricultural extension service agents from 10 Zonal districts. Focus group discussions and key informant interviews were conducted to acquire data from policymakers and important informants. The data was examined in light of the study's research topic.

3.4. Method of Data Analysis

The study's research question directed the analysis of the data, which also involved the application of descriptive statistical tools for simple raw data presentations, as well as leaders in agricultural extension and mechanization from the study area providing the data. The data was then analyzed using a variety of techniques, including tables and figures. The techniques used to analyze the data included the level of mechanization, estimation of the mechanization index, and measurement of productivity on the farm.

3.4.1. Measurement of the Level of Mechanization

Farm machinery is a crucial component of the agricultural production system that enables various equipment types to be operated to complete agricultural tasks on time, boost output, and keep a farm sustainable. The following Equation (1) is used to calculate the level of mechanization [39].

$$Mecanization\ level\left(\frac{hP}{ha}\right)=\frac{TP}{CA} \tag{1}$$

Where:

hp refers to horsepower;
ha refers to hectare;
TP refers to total power of existing tractors;
CA refers to the cultivation area.

The total real power of tractors is the product of the total power of existing tractors and conversion coefficient (0.75); whereas animal energy (hp-h) is the product of total existing animal power and annual functional hours; mechanization level (hp·ha^{-1}) is the total power of existing tractors (TP) per cultivation area (CA), in which one horsepower is equivalent to 0.75 kilowatt and one human power per hectare is equal to 0.125 hp.

3.4.2. Estimation of Mechanization Index

The mechanization index (MI), which is computed using Equation (2), is a percentage that reflects the proportion of the area's labor that is performed by tractors, humans, and machinery. According to Carruthers and Rodriguez [40], the technique was developed for Italian farmers and involves using two oxen to pull a tiller that is being operated by a person. With five farmers on each farm, a four-wheeled tractor can plow one hectare in three hours and twelve minutes, yet human labor only requires 0.125 horsepower per hectare in 4 hours to 4 hours and 48 minutes. This index provides an evaluation and rating of the various levels of mechanization used in a certain location [41]. It was determined by using Olosunde's study [30] in Equations (2) and (3).

$$Mecanization\ Index\ (MI)=\frac{LM}{LT} \tag{2}$$

Where:

MI = Mechanization index (%);
LM = Average sum of all mechanical operation work of the machine (kWhr·ha^{-1});
LH = Average work outlay by human powered (kWhr·ha^{-1});
LT = Average work outlay by human and machine.

Powered Machines, kWhr·ha^{-1}

$$LT=LM+LH \tag{3}$$

3.4.3. Measurement of Farm Productivity

Based on the production schedule principle, given the technology available showed the maximum output (per hectare) that can be produced from a given combination of inputs, it is possible to calculate the productivity of both human and machine labor. Numerous productivity metrics can be computed, but one general metric is the ratio of the cereal crop difference between mechanized and non-mechanized in quintal per hectare. The mathematical expression for the productivity of labor, machines, and overall productivity developed by Ortiz-Canavate and Salvador [42] is presented in Equation (4):

$$Productivity\,(\%)=\frac{(MOP-NMOP)}{(NMOP)}\times 100\% \tag{4}$$

Where:

MOP refers to mechanized output farm productivity, which is the amount of work completed as a result of the machinery used.
NMOP stands for non-mechanized output farm productivity of labor, which is the work completed by the labor force used.

4. Results

4.1. Focus Group Discussion and Key Informant Interview

Focus groups and key informant interviews were conducted separately at the stakeholder level in the central Ethiopian region, Hadiya zone, and zonal districts[43]. Of the 23 participating stakeholders, 91.7% were men and 8.3% were women, all of whom were over 35 years old. 13 key informant interviews and group discussions were conducted with 10 participants. In Hadiya zone central Ethiopia, the study looked at the relationship between farm productivity and the use of farm machinery. In key informant interviews, 84.5% stated that over 85% of farmers in the Hadiya zone use hand tools and animal draw technology, and a significant number of respondents agreed that low farm productivity results from low machinery utilization. 90% of respondents stated that there are relatively few services that are accessible for agricultural machines. Stakeholders' responses support the poor productivity of farmland and little use of agricultural equipment.

4.2. Farm Availability and Machinery Utilization

The available land for Mechanization and machinery utilization for the last five years in the Hadiya zone is depicted in **Table 1**. As revealed in **Table 1**, the total available farmland for mechanization increased from 128,147 in 2019 to 146,551 hectares in 2023 and from available farmland for mechanization 16.98 % mechanized in 2019 and 20.81 % was in 2023 using agricultural machinery from the government by subsidy and private rent. The ratio of farm tractors to available land (measured in hectares) is one tractor for every 18,306 hectares in 2019 and one for every 3574 hectares in 2023.

Table 1. Non-mechanized and mechanized farm productivity in cereal crops per hectare in 5 years in Hadiya zone.

Year	Available Land for Mechanization (ha)	Mechanized Land (ha)	Number of Machinery (Subsidy and Private Rent)		
			Tractor	combiners	Threshers
2019	128147	21762	2 + 5	2 + 2	0 + 2
2020	128504	24451	4 + 5	3 + 5	2 + 4
2021	132238	26434	10+13	3 + 6	3 + 4
2022	139926	28992	14+18	5 + 9	5 + 6
2023	146551	30508	20+21	5 + 10	5 + 6

4.3. Machinery Utilization and Farm Productivity for Five Years in Hadiya Zone

The data for the last five years' farm machinery utilization and farm productivity both mechanized and non-mechanized for cereal crop productivity per hectare are shown in **Table 2** below. Over the previous five years, the Hadiya zone's farm productivity have increased concerning cereal crops. For example, wheat productivity increases from 46 to 80 quintal·ha^{-1} in 2019 and from 42 to 55 quinta·ha^{-1} in 2023; while maize productivity increases from 37 to 55 quintal·ha^{-1} in 2019 and from 32 to 50 quintal·ha^{-1} in 2023. Similar trends are shown for the conditions of the two remaining cereal crops, barley, and teff (**Table 2**).

Table 2. Non-mechanized and mechanized farm productivity in cereal crops per hectare in 5 years in Hadiya zone.

Year	Non-Mechanized Farmland Per Hectare (Quintal)				Mechanized Farm Land Per Hectare (Quintal)			
	Wheat	Maize	Teff	Barley	Wheat	Maize	Teff	Barley
2019	46	37	14	40	80	55	20	62
2020	45	35	13.5	38	78	54	19	60
2021	45	35	12	35	66	52	18	55
2022	45	33	12	35	65	50	18	52
2023	42	32	12	34	55	50	18	52

4.4. Farm Land Availability and Current Tractor Utilization in Each District in Hadiya Zone

The available land for mechanization, mechanized farmland and number of tractors in the zonal districts are depicted in **Table 3**. Only 30,508 hectares of the 146,551 hectares of currently available farmland for mechanization in each Zonal district is mechanized, with the utilization of 41 farm tractors. According to these findings, more than 85% of farmers in the research area use hand tools and animal-drawn equipment. This is true since the majority of farmers do not have the financial resources to buy equipment like tractors and ploughs. Ethiopian Polices on agricultural mechanization can have a significant impact on the food security of households. The amount of farmland that is currently mechanized varies depending on the district's distribution of farmland. For instance, the mechanization of farmland is highest in the Anlemo district (26.78%) and lowest in the Misrak Bedawacho district (16.91%), with a zonal average of 20.80%. The zonal horsepower utilization level per hectare for available farmland for mechanization is 0.032, and that for mechanized farmland is 0.15.

The t-test value in **Table 4** showed significant differences among the selected districts of available tractor and average horsepower and a positive correlation exists between the variables (r = 0.58).

4.5. Current Farm Productivity of Non-Mechanized and Mechanized Farmland Cereal Crops Per Hectare in Hadiya Zonal Districts

The highest cereal productivity per hectare in each zonal district, from non-mechanized to mechanized is shown in **Table 5**. These are wheat, maize, teff, and barley, respectively, 44 to 66 in Duna, 35 to 55 in Shashogo, 14 to 18 in Misrak Bedawacho, and 35 to 52 in Soro district in quintal per hectare. The average zonal present agricultural productivity is 42, 32, 12, and 32 quintals per hectares for non-mechanized farmland and 55, 50, 16, and 48 for mechanized farmland, respectively. The results of this study demonstrated that production depends on the use of farm machinery and that very few farmlands are mechanized.

Table 3. Available farmland for mechanization, mechanized farmland, and number of machinery in zonal districts.

District	Available Farmland for Mechanization (ha)	Mechanized Farmland (ha)	Tractor	Average (hp)
Misrak Bedawacho	17174	2907	3	100
Mirab Bedawacho	9926	1751	2	100
Lemo	19538	4192	7	121
Anlemo	8177	2272	3	121
Soro	22433	4194	6	121
Misha	14458	3528	4	121
Gibe	14617	2954	4	121
Gombora	15458	3449	4	125
Shashogo	9040	2349	4	117
Duna	15731	2912	4	117
Total	146,551	30508	41	116

Table 4. T-test comparison of available tractor and average horsepower at various districts.

	Tractor	Average (hp)
Mean	4.10	116.32
Variance	2.10	79.74
Observations	10.00	10.00
Pearson correlation	0.58	
Degree of freedom	9.00	
t stat	43.42	
P(T <= t)	0.00	
t critical	1.83	

4.6. Measurement of Machinery Utilization and Productivity

4.6.1. Measurement of the Level of Mechanization

Lemo district has the highest average mechanical power availability in terms of horsepower per hectare ($hp \cdot ha^{-1}$) at 0.20, followed by Misrak Bedawacho district at 0.1 $hp \cdot ha^{-1}$, and the Hadiya zone as a whole at

Table 5. Farm productivity of cereal crops in non-mechanized and mechanized zonal district in quintal per ha.

District	Non-Mechanized Farm Land (Quintal Per ha)				Mechanized Farm Land (Quintal Per ha)			
	Wheat	Maize	Teff	Barley	Wheat	Maiz	Teff	Barley
Misrak Bedawacho	-	35	14	-	-	50	18	-
Mirab Bedawacho	-	25	12	-	-	35	15	-
Lemo	42	-	12	32	55	-	16	49
Anlemo	43	-	12	32	55	-	16	50
Soro	45	-	12	35	60	-	16	52
Misha	40	-	-	32	50	-	-	42
Gibe	42	32	-	32	52	50	-	43
Gombora	40	33	-	32	50	50	-	51
Shashogo	40	35	13	33	65	55	16	45
Duna	44	-	-	32	66	-	-	51
Average	42	32	12	32	55	50	16	48

0.15 hp·ha^{-1} (**Figure 2**). Human labor remains the main input employed in cereal crop agricultural operations in the Hadiya zone.

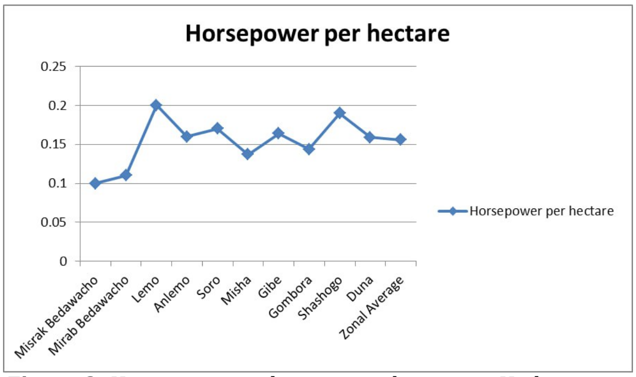

Figure 2. Horsepower utilization per hectare in Hadiya zone.

4.6.2. Estimation of Mechanization Index

The Hadiya zone's total four-wheel tractor (41) work was 11,445.8 kilowatt hours, its total human labor (96,702) work using was 43,516.27 kilowatt hours, mechanization index which came out to be 20.8%. The results found that the Misrak Badawacho district had the lowest amount of breakdowns during operations (11.88%) and the Shashogo district had the highest rate (30.85%) in their respective districts (**Table 6**). This showed that the energy input of human labor per hectare of land is larger than that of machines as the index value of mechanization grows.

4.6.3. Measurement of Productivity

The productivity variation was compared with each farm's mechanization and cultivated land levels, as shown in **Table 7**. Crop yields are a measure of the physical productivity of a particular plot of land and are impacted by the level of technology applied. The biggest productivity differences were seen in cereal crop cultivation: Shashogo in wheat (62.5%), Shashogo in maize (57.1%), (Lemo, Anlemo, and Soro) in teff (33.3%), and Anlemo in barley (56.3%). The lowest production differences are found in Gibe (wheat), Mirab Bedawacho (maize), Shashogo (teff), and Misha (barley), with respective percentages of 23.8%, 40.0%, 23.1% and 31.2% (**Table 7**). The productivity for cereal crops on a zonal average is 34.8%, 47.85%, 29.41%, and 46.58% for wheat, maize, teff, and barley, respectively.

5. Discussions

Agricultural machinery plays a major role in today's agricultural productivity. However, Ethiopia has continued to have a very low rate of adoption of agricultural machinery, especially in the Hadiya zone. Utilizing farm machinery has been crucial in bringing about a major shift in technology crop production [44]. The result from focus groups and key informant interviews which were conducted separately among the 23 participating different stakeholders, the study looked at the relationship between farm productivity and the use of farm machinery. In key informant interviews, 84.5% stated that over 85% of farmers in the Hadiya Zone use hand tools and animal-drawn technology, and a significant number of respondents agreed that low farm productivity results from low machinery utilization. 90% of respondents pointed out during the focus group discussion that there were relatively few services that are accessible for types

Table 6. Energy consumption for humans and tractors, and mechanization index.

Districts	Tractor Energy Consumption (kwh)	Human Energy Consumption kwh)	Mechanization Index (%)
Misrak Badawacho	720	5350	11.88
Mirab Badawacho	480	3065	13.54
Lemo	2092	5754	26.66
Anlemo	871	2214	28.23
Soro	1742	6839	20.30
Misha	1661	4098	28.84
Gibe	1661	4373	27.52
Gombora	1200	5796	15.90
Shashogo	1119	2508	30.85
Duna	1119	4807	18.87

Table 7. Increased percentage of farm productivity in cereal crop.

District	Crop Productivity of Crop (%)			
	Wheat	Maize	Teff	Barley
Misrak Badawacho	-	42.8	28.5	-
Mirab Badawacho	-	40.0	25.0	-
Lemo	30.9	-	33.3	53.1
Anlemo	27.9	-	33.3	56.3
Soro	33.3	-	33.3	48.6
Misha	25.0	-	-	31.2
Gibe	23.8	-	-	51.5
Gombora	25.0	51.5	-	36.3
Shashogo	62.5	57.1	23.1	36.3
Duna	50.0	-	-	59.4
Zonal Average	34.8	47.9	29.4	46.6

of agricultural machinery, consequently, farm mechanization of farming operations is highly necessary [45].

Of available farmland for mechanization, 16.98% was mechanized in 2019 and 20.81% was in 2023 using agricultural machinery from the government by subsidy and private rent. The ratio of farm tractors to available land is one tractor for every 18,306 hectares in 2019 and one for every 3574 hectares in 2023; this implies very low tractor distribution per hectare. Our data showed differences between non-mechanised and mechanised fields for wheat from 46 to 80 quintal·ha^{-1} in 2019 and from 42 to 55 quintal·ha^{-1} in 2023, while maize observed increases from 37 to 55 quintal·ha^{-1} in 2019 and from 32 to 50 quintal·ha^{-1} in 2023. Unfortunately, in the Hadiya zone the term "farm machinery mechanization" as predicted, even though its true goal improving labor and land productivity is frequently not well understood [46]. This is confirmed by Ayele [11]: for several decades, Ethiopia's agricultural development initiatives have included smallholder mechanization. According to the study by Fentie and Beyene [47] in 2025, Ethiopia could transform into a middle-income nation with the use of suitable agricultural technology [48]. However, insufficient use of science and technology is still the reason for land productivity gaps not only in the study area but also across sub-Saharan African agriculture [49].

The amount of farmland that is available for the farm tractors to use that land for mechanization ratio calculations increased between 2019 and 2023. This study related to the finding of Mirpanahi, Almassi and Javadi [50], but very little machinery utilization in the study area. The productivity at which un-mechanized to mechanized cropland was converted to wheat increased from 46 to 80 quintal·ha^{-1} in 2019 and from 42 to 55 quintal·ha^{-1} in 2023. Similarly, the productivity at which maize converted from non-mechanized to mechanized cropland was 37 to 55 quintal·ha^{-1} in 2019 and 32 to 50 quintal·ha^{-1} in 2023. The similar conditions were for the two remaining cereal crops, teff and barley in which the crop productivity also increased in line with zonal status [51], but cereal crop yield declined because climate-smart agriculture was not practiced. This is due to the lack of climate-wise agriculture led to the decline in cereal crop yield, which is corroborated by the prediction that upland grain-based labor, land, and livestock income will fall by 5.1%, 8.8%, and 15.2% in 2050 due to insufficient moisture [52]. This result has shown that the zonal districts, and the distribution of farmland within districts themselves determines the amount of farmland that is currently mechanized. For example, with a zonal average of 20.80%, the percentage of agriculture mechanized is the highest in the Anlemo district (26.78%) and the lowest in the Misrak Bedawacho district (16.91%), This indicated that low mechanical operated activities which was confirmed by other authors elsewhere [53].

While accessible farmland has a zonal horsepower usage level of 0.032 per hectare, mechanized farmland has a zonal horsepower utilization level of 0.15. In their respective districts, Misrak Badawacho had the fewest operational problems (11.88%); while Shashogo had the most (30.8%). This demonstrated that when the index value of mechanization decreases, the energy input of human labor per hectare of land is greater than that of machines this is due to the shortage of access to farm machinery [54]. This result is the consequence of the experience of farmers, minimal involvement from the commercial sector, and sparse distribution of machinery; these factors are comparable to the finding of Mebratu [45] and more than 85% of these farmers hired human labor, draught, and/or engine power [55].

6. Conclusions and Recommendations

From this study the following conclusions were made: the amount of agricultural mechanization and farmland productivity in the Hadiya zone of central Ethiopia for 122,126 households owning 146,5510 hectares of accessible land for mechanization reported 41 farm tractors, 15 combiners and 11 threshers in use. The increase in cereal fields is highly associated with both tractor-plowed and animal-plowed. Cropland area has grown by average of 12% for every additional hectare for the last five years that a tractor ploughs. Only 16.8% and 20.81% of the farmland which is accessible for mechanization were mechanized in 2019 and 2023, respectively. Compared to the amount of farmland which is available for machinery usage, the level of agricultural machinery utilization is quite low. The Ethiopian government has a significant role in enhancing the use of machinery; however, in the Hadiya zone, focus should be placed on machinery access. To date, several actions need to be made to boost the agriculture sector's growth particularly utilization of agricultural machineries in Hadiya zone.

To increase the productivity of land and labor through timely operations, efficient input use, and improvement in a duality of produce, safety, and reduction in produce loss and farmer drudgery, improved farm implements and machinery must be typically used for various farm operations. Mechanization encourages intensive farming practices, which increases the amount of food available to vulnerable and underprivileged groups (such as landless farmers and agricultural workers with less drudgery). Farm mechanization benefits both farmers and agricultural workers.

There is a strong correlation between farm machinery use and farm productivity, and it is recommended that the central Ethiopia regional government should encourage the proper use of agricultural machinery that is affordable for subsistence farmers through a rental basis or credit system; to use farm machinery and apply the cluster farming system for small landholding in an appropriate manner for each district in the Hadiya zone to significantly increase crop productivity.

7. Limitation of the Study

The natural resource base has been exploited by modern farming practices, and these practices need a substantial financial investment. A detailed examination of how modern equipment is used on farms and how this affects productivity and efficiency is necessary to improve the assessment of current farm machinery utilization and farm production. It would be advantageous to look at the kinds and states of the machinery employed as well as how effectively it works for different agricultural jobs and how well it contributes to labor cost savings and crop yield optimization. By examining data on maintenance schedules, operational expenses, and machinery usage patterns, authors have identified key domains where incorporating technology could enhance efficiency. Furthermore, the evaluation should consider how well the capabilities of the machinery align with the specific needs of different farming operations. This comprehensive approach will provide valuable insights into current equipment that supports sustainable agricultural practices and contributes to the economic viability of farms, particularly in the Hadiya zone of central Ethiopia.

Author Contributions

Conceptualization: D.Y., K.P.K., M.D. and M.M.; Formal analysis: D.Y., M.D. and M.M.; Investigation, D.Y. and M.D.; Methodology: D.Y., K.P.K., M.D. and M.M.; Supervision: K.P.K., M.D. and M.M.; Writing—original draft: D.Y.; Writing—review & editing: K.P.K., M.D. and M.M.; Fund acquisition: M.M. The published version of the manuscript has been read and approved by all authors.

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Data Availability Statement

The data presented in this study are available upon request from the first author.

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Conflict of interest

The authors listed above have no competing interests.

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