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Determination of the Agricultural Mechanization Level of Agricultural Enterprises in Eskil District of Aksaray Province

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HIGHLIGHTS

- In Eskil district of Aksaray province, the average agricultural enterprise size is 459.62 decares, and irrigated farming is carried out on all cultivated land. This numeral is approximately six times larger than the national average in Turkey, which is around 76 decares.
- Wheat (40.94%) is the most widely cultivated crop in the agricultural production area. Other important crops, cultivated both as feed and industrial crops, include barley (17.48%), grain corn (16.10%), silage corn (9.54%), sugar beet (7.30%), and alfalfa (7.14%).
- The average age of tractors in the region is 5.5 years, with an average engine power of 79.12 kW. Compared to the national average, tractors in Eskil are significantly newer and more powerful. Notably, 75% of the tractor park is between 1 and 5 years old.
- Only 21.70% of the enterprises engage in both crop and livestock production. This rate is below the national average and indicates a need for greater integration of plant and animal farming to support sustainable agriculture.

Abstract

In this research, the agricultural structure, production, and mechanization characteristics of agricultural enterprises in the Eskil district of Aksaray province were determined. Data were collected through face-to-face surveys determined with 106 agricultural enterprises, which were selected using a stratified sampling method in the Eskil district. As a result of the research, it was determined that the average farming duration was 34.8 years, the average age of the farmers was 45 years, the average number of family members was 4.75, and 44.34% of the farmers were high school graduates, while 5.66% had higher education degrees. It was determined that the enterprises owned an average of 226.93 da of agricultural land, with approximately 459.62 da of land per enterprise used for the production of 2.5 different crop types. In Eskil district, 68.87% of the enterprises cultivated wheat, 49.06% cultivated grain maize, 45.08% cultivated barley, 35.85% cultivated silage maize, 22.64% cultivated sugar beet, and 19.81% cultivated alfalfa. The study also found that the number of tractors per enterprise was 1.74, with an average tractor engine power of 137.34 kW per enterprise. The average tractor power was

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79.12 kW, and the average tractor age was 5.5 years. Additionally, there were 6.80 implements and machines per tractor, with an average implement-machine weight of 6.07 tons per tractor. Regarding mechanization density, it was determined that there were 37.76 tractors per 1 000 ha, with each tractor working on 26.48 ha of cultivated land. The number of combine harvesters per 1 000 ha was found to be 0.62.

Keywords: Eskil District; Mechanization Level; Agricultural Mechanization; Agricultural structure

1. Introduction

The rapid increase in the world population is hindering people's access to basic food and causing nutritional problems. According to FAO data, in 2022, 9.2% of the global population, approximately 735 million people, were affected by global hunger (FAO 2023). Agricultural production plays a critical role in food security, economic development, environmental sustainability, and technological advancement. However, the sustainability of current agricultural production systems needs to be re-evaluated in light of the growing global population. Furthermore, in the coming years, agricultural policies must be shaped around sustainability and innovative approaches to ensure long-term resilience and efficiency.

Agricultural mechanization is a scientific discipline that encompasses all activities related to design, manufacturing, development, marketing, agricultural extension, agricultural education, selection, operation, repair and maintenance, and protection of various types of agricultural tools and machines powered by different energy sources and mechanical power. These technologies are essential for developing agricultural areas, conducting all types of agricultural production, and processing agricultural products (Ertekin et al. 2021). Within production technologies, agricultural mechanization holds a distinctive position. It is a crucial and complementary element that enhances the efficiency of other technological applications, ensures economic feasibility, and improves working conditions in the agricultural sector.

The impact of machines used in agriculture on increasing crop yield depends on several factors, including land availability, parcel size, soil structure, climatic conditions, crop pattern, production techniques, the type and capacity of machines used, tractor power, compatibility with agricultural machinery, and skilled labor. These factors can individually or collectively contribute to improving productivity. Additionally, agricultural enterprises must be at a sufficient level in terms of knowledge and optimal input usage to achieve maximum efficiency in agricultural mechanization.

In Turkey, numerous studies have been determined at the province, regional, and national levels to establish agricultural mechanization databases using survey studies and statistical data. Some of the recent studies focusing on agricultural mechanization include; Amasya province (Dertlioğlu and Altuntaş 2023), Şırnak province (Toraman 2023), Tokat province (Gül et al. 2022), Turkey-wide analysis (Aybek et al. 2021), Niğde province (Saygılı and Çakmak 2021), Konya Plain Project Region (Malaslı et al. 2020), Çanakkale province (Özpınar 2020), Karaman province (Kaya and Örs 2020), Çankırı province (Çanakcı and Kaba 2019), Turkey, Thrace Region, Edirne, Kırklareli, and Tekirdağ provinces (Abdikoğlu 2019). These studies assess the agricultural production potential along with the availability of agricultural mechanization tools, determine mechanization levels and challenges, and provide solution-oriented recommendations.

Eskil district is part of Aksaray province, and agriculture and livestock farming play a significant role in the local economy and employment. A review of existing literature revealed that no dedicated research has been determined to identify the agricultural mechanization characteristics specific to the Eskil district. This study aims to fill the existing research gap by evaluating the mechanization structure and agricultural characteristics of the Eskil district, where no such comprehensive study has been determined to date. The findings provide valuable data that can support policy-making, strategic planning, and interregional comparative studies.

2. Materials and Methods

Aksaray is a province located in the Central Anatolia Region of Turkey, partially situated in the Konya Basin and partially in the Cappadocia region. The province consists of 8 districts including the central district,

22 municipalities, 157 neighborhoods within these municipalities, and additionally 175 villages (Anonymous 2023a). Aksaray is bordered by Nevşehir to the east, Niğde to the southeast, Konya to the west, Ankara to the north, and Kırşehir to the northeast. It has a surface area of 7 997 km² (Anonymous 2025a).

Eskil District is located to the south of Lake Tuz, approximately 67 km from Aksaray and 115 km from Konya, and is generally established on a flat plain. It lies along the Aksaray–Konya state highway. It is bordered by Lake Tuz to the north, towns and villages of Konya Province to the west, the Karapınar district of Konya to the south, and towns and villages of Aksaray Province to the east. Eskil experiences a typical continental climate characteristic of the Central Anatolia Region (Anonymous 2023b).

It is one of the largest districts of Aksaray province in terms of agricultural intensity and population. According to the 2022 census, the population of Eskil was recorded as 27 188 people. The district consists of 1 town, 11 villages, and 17 neighborhoods within the central area. Eskil covers a total area of approximately 1 152 km². The total male population is 13 889 and the total female population is 13 299, 51.08% of which is male and 48.92% is female (Anonymous 2025b). The geographical map of Aksaray is shown in Figure 1 (Anonymous 2025c).

Figure 1. Geographical Map of Aksaray Province

Eskil district is the most significant agricultural center in Aksaray province due to its different crop patterns and widespread irrigated farming. For this reason, it was selected as the research area for this study. There is a total agricultural area of 609 660 da in the district, silage and grain corn is produced in 226 414 da, wheat in 168 174 da, barley in 99 393 da, alfalfa in 35 564 da and sunflower in 14 764 da (Anonymous 2023b).

In the research, a sampling method was used in the process of collecting primary data. The population of the study consisted of 3 286 agricultural enterprises registered in the ÇKS (Farmer Registration System) in Eskil district. The sample size was determined using the Simple Random Sampling Method according to the Neyman Method, and the corresponding formula is expressed as follows (Yamane 1967).

$$n=\frac{N_p(1-p)}{(N-1)\sigma^2_{p_x}+p(1-p)}, \quad (1)$$

In the formula;

n : Sample size
N : Number of enterprises in population
σ_{px}^2 : Variance of the rate
p : 0.5

The sample size representing the population was determined to be 106 at a 99% confidence level with a 10% margin of error (Çiçek and Erkan 1996). The stratification of agricultural enterprises by land size, along

with the corresponding number of surveys and the number of enterprises allocated to each stratum, is shown in Table 1.

Table 1. The Number of Determined Agricultural Enterprises

Layers	Number of Enterprises	Number of Surveys
I. Layer (0-49 da)	609	2
II. Layer (50-199 da)	1362	18
III. Layer (200-499 da)	925	24
IV. Layer (500 da+)	390	62
Total	**3 286**	**106**

The agricultural land sizes have been examined in four layers and classified as follows: the first layer includes areas between 0 and 49 decares, the second layer covers 50 to 199 decares, the third layer ranges from 200 to 499 decares, and the fourth layer consists of 500 decares and above.

Face-to-face surveys were conducted with agricultural enterprises to represent the designated layer. The data obtained was supported by observation techniques. The data obtained were further enriched through direct field observations. The survey explored various aspects including enterprise characteristics, farming structure, land use, production practices, ownership of tractors and other agricultural machinery, and the level of mechanization.

Additionally, within the scope of the survey, the characteristics of the agricultural machinery park were determined, and data from agricultural machinery manufacturers companies were utilized.

The following criteria have been used to determine the mechanization level of enterprises:

- Number of tractors per enterprise (tractors. enterprises^{-1})
- Tractor engine power per enterprise (kW. enterprise^{-1})
- Average tractor power (kW. tractor^{-1})
- Number of implements and machines per tractor (implements and machines. tractor^{-1})
- Weight of implements and machines per tractor (tons. tractor^{-1})
- Cultivated land per tractor (ha. tractor^{-1})
- Tractor engine power per unit area (kW. ha^{-1})
- Number of tractors per 1 000 ha [tractors (1 000 ha) $^{-1}$]
- Number of combine harvesters per 1 000 ha [harvesters (1 000 ha) $^{-1}$]

In the evaluation of the research findings, the Statistical Package for the Social Sciences (SPSS) software was employed to conduct quantitative data analysis. The data obtained from field surveys were systematically coded and entered into the SPSS environment for statistical processing. During the analysis phase, descriptive statistical methods such as frequency distribution, percentage calculations, and arithmetic mean were utilized to summarize and interpret the general characteristics of agricultural enterprises. Furthermore, the chi-square (χ^2) test was applied to examine potential relationships and associations between variables such as education level, number of livestock, and fuel consumption of tractors across different layer. This approach enabled the identification of statistically significant differences or dependencies within the dataset, thereby enhancing the validity and interpretability of the research results.

3. Results and Discussion

3.1. Demographic Characteristics of Farm Owners

In Eskil district, the ages of farm owners range from 20 to 82 years, with an average age of 45 years. It has been determined that, considering all enterprises, 32.08% of farm owners are between the ages of 50 and 60.

In comparison, the average age of farmers in the United States is reported to be 58 years, in Japan 67 years, and in Europe, more than one-third of farmers are over the age of 65 (Anonymous 2024a). In our country, the ages of farmers range from 19 to 90 years, with an average age of 53.4 years. Additionally, the rate of young farmers (under 40 years old) is reported to be 14% (Anonymous 2023d). The relatively low average age of farm owners in Eskil district (45 years) and the high proportion of young farmers (32.70%) indicate that agricultural enterprises in the region are managed by a younger generation.

As part of the survey, it was found that the operational duration of agricultural enterprises ranges from 4 to 75 years, with an average farming experience of 34.8 years. In the Harran Plain of Şanlıurfa province, 38% of agricultural enterprises have been engaged in farming for 11 to 20 years (Bozkurt and Aybek 2016), while in Çankırı province, the average farming experience of agricultural enterprises is reported to be 28.6 years (Çanakcı and Kaba 2019). Based on these findings, it can be stated that farmers in Eskil district are experienced.

Education level has a significant impact on individuals' behaviors. The educational background of farm owners is shown in Table 2. It was found that 44.34% of farm owners are high school graduates, 33.02% have completed primary education, 16.98% have secondary education, and 5.66% hold a university degree. According to the Chi-square test results, no statistically significant relationship was found between the education levels of farmers and the enterprise layers (p=0.854). In comparison, 75% of farm owners in Çankırı province have only a primary education (Çanakcı and Kaba 2018), while in Uşak province, 38.36% of enterprises engaged in black cumin production are primary school graduates (Can 2020). These results suggest that farmers in the surveyed area possess a relatively high level of education, which could facilitate their ability to embrace innovations and apply modern agricultural methods.

Table 2. Educational Background of Farm Owners

Educational Status of Farm Owners							
Layers	Primere Education	Secondary Education	High School	Associate degree	Bachelor's degree	Master's Degree	Total
I	-	-	2 (100%)	-	-	-	2
II	5 (27.78%)	3 (16.67%)	9 (50%)	-	1 (5.56%)	-	18
III	7 (11.29%)	5 (8.06%)	10 (16.13%)	2 (3.23%)	-	-	24
IV	23 (37.10%)	10 (16.13%)	26 (41.94%)	1 (1.61%)	1 (1.61%)	1 (1.61%)	62
Total	35 (33.02%)	18 (16.98%)	47 (44.34%)	3 (2.83%)	2 (1.89%)	1 (0.94%)	106
$\chi 2$ =9.42; SD=15; P-değeri=0.854							

3.2. Number of Family Person

The average number of individuals per enterprise ranges between 2 and 7, with an average of 4.75. Özpınar and Ürkmez (2017) reported that the average number of family members per agricultural enterprise in Çanakkale province is 3.72, while Aydın and Unakıtan (2016) stated that the number of family members per producer in Edirne, Kırklareli, and Tekirdağ provinces is 3.47. Additionally, Kayhan et al. (2017) reported that the average family size in Kırklareli province is 3.56. Turkey, young farmers should be encouraged to contribute to agricultural production, and efforts should be made to increase the number of family members involved in agricultural labor. From this perspective, the fact that the average family size in Eskil district is 4.75, which is higher compared to recent research findings, is promising for the future.

3.3. Economic Structure of Enterprises

In Eskil district, the total agricultural land owned by enterprises amounts to 24 055 decares, with an average of 226.93 decares per enterprise. In comparison, the average land size in Turkey is 76 decares (Anonymous 2019), while in Çumra district, the average privately owned land per enterprise is 105.33 decares (Keleş and Hacıseferoğulları 2016). Based on these to the numbers, it can be stated that the land sizes of enterprises in the research area are above the national average. The rented land area varies between 31 and 1 600 decares, with an average of 229.53 decares per enterprise, and the total rented land is 24 330 decares. It has been determined that all owned and rented agricultural lands are used for irrigated farming. Only one enterprise engages in joint agricultural production on 325 decares, while another enterprise has left 10 decares fallow. The total agricultural land used for farming amounts to 48 720 decares, with an average of approximately 459.62 decares

per enterprise. The size of agricultural lands varies between 32 and 2 000 decares. It has been determined that parcel sizes range between 2 and 600 decares, with the most general parcel size being 200 decares, accounting for 6.30% of all parcels. The average parcel size in Eskil district is 133.48 decares. The number of parcels In Turkey, agricultural enterprises with 2 to 5 parcels constitute 57.40% of the total number of enterprises, accounting for 44.18% of the total parcels and 50.76% of the total agricultural land (Kuşlu 2023). Additionally, a significant number of enterprises are reported to own 6 to 9 parcels. Another study determined that the average number of parcels per enterprise in Turkey is 5.9 (Anonymous 2019). Currently, the support policies implemented in Turkey may be insufficient in ensuring the sustainability of small-scale agricultural enterprises. Supporting large agricultural areas and implementing land consolidation projects are crucial in addressing this issue.

3.4. Agricultural production of Eskil district

All enterprise included in the survey was actively full in crop cultivation. In addition, 21.70% of these enterprises also carry out livestock activities. A total of 23 enterprises operate in both crop and livestock production. Of these enterprises, just one is involved in the fattening of small ruminants, whereas another specializes in dairy production from small ruminants. Furthermore, 11 enterprises are concerned in cattle fattening, while 10 are involved in cattle dairy farming. One enterprise performs both cattle fattening and dairy production simultaneously. In Turkey, the proportion of enterprises engaged solely in crop production is 64%, while 36% of enterprises carry out both crop and livestock production. The role of mixed (integrated) farming enterprises is emphasized on international platforms, highlighting their contribution to ensuring economic, social, and environmental sustainability in the agricultural sector. Moreover, it is stated that a decrease in the number of mixed farming enterprises may indicate a decline in the agricultural production system (Anonymous 2023d). The cultivated areas for crop production, yield values, and the number of enterprises by layer in the Eskil district are shown in Table 3.

Table 3. Status of Crop Production in Agricultural Areas

Crop Type	Production Area (da)	Yield (kg da^{-1})	Number of Enterprises by Layer				Total Enterprises
			I	II	III	IV	
Grain Corn	7 843 (16.10%)	1 390.38	1	6	6	35	52 (49.06%)
Silage Corn	4 646 (9.54%)	7 238.94	-	5	4	29	38 (35.85%)
Triticale Silage	20 (0.04%)	4 000.0	-	-	-	1	1 (0.94%)
Sugar Beet	3 557 (7.30%)	10 270.79	-	3	5	16	24 (22.64%)
Barley	8 513 (17.48%)	933.33	-	5	7	36	48 (45.08%)
Wheat	19 940 (40.94%)	867.61	1	15	18	49	83 (68.87%)
Potato	122 (0.25%)	5 000.0	-	-	-	1	1 (0.94%)
Garlic	5 (0.01%)	1 800.0	-	-	-	1	1 (0.94%)
Sunflower (Seed)	471 (0.97%)	441.67	-	1	1	1	3 (2.83%)
Sunflower (Oil)	94 (0.19%)	168.38	-	-	-	2	2 (1.89%)
Alfalfa	3 477 (7.14%)	8 452.38	1	4	4	12	21 (19.81%)
Tomato	5 (0.01%)	7 500.0	-	-	-	1	1 (0.94%)
Black Cumin	17 (0.03%)	90.0	-	-	-	1	1 (0.94%)
Total	48 710 (100%)		2	34	51	165	

The data offer valuable insights into crop preferences, production scale, and mechanization levels among local agricultural enterprises. Survey results revealed that farms grow between 1 and 6 different crops, with an average of 2.5 different crop types per enterprise.

Wheat is the most widely cultivated crop, accounting for 40.94% of the total agricultural land (19 940 da), produced by 83 enterprises (68.87%). The average yield is 867.61 kg da^{-1}.

Barley and grain corn follow wheat in terms of cultivated area, with 8 513 da (17.48%) and 7 843 da (16.10%), respectively. Barley is cultivated by 48 enterprises (45.08%), while grain corn is grown by 52 enterprises (49.06%). These two crops are primarily preferred due to their significance as animal feed and their potential for economic return

Silage corn covers an area of 4 646 da (9.54%) and is notable for yield of 7 238.94 kg da^{-1}. It serves as a key feed crop for enterprises engaged in cattle farming and is predominantly cultivated by enterprises in Layer IV, which comprises farms with large landholdings. This indicates that silage corn cultivation demands higher levels of investment and mechanization.

Sugar beet is different high-yield crop (10 270.79 kg da^{-1}) grown on 3 557 da (7.30%) by 24 enterprises (22.64%), reflecting the district's integration with agro-industrial production chains.

Alfalfa, cultivated on 3 477 da (7.14%), shows a high yield of 8 452.38 kg da^{-1}, indicating its importance in supporting mixed farming systems (crop and livestock production). Its prominence reinforces the coexistence of animal husbandry with plant production in the district.

Crops such as sunflower (seed and oil), potato, garlic, black cumin, and tomato are cultivated in limited areas by a small number of enterprises.

An analysis of enterprise layers reveals that most of the agricultural production is intensive in Layer IV, indicating that large-scale farms dominate the district's agricultural activities. These farms typically cultivate a wider variety of crops and are more actively involved in high-yield, commercially driven production systems.

In Turkey, farmers commonly apply crop rotation practices on different parcels and cultivate an average of 3 to 4 crop types. This diversified crop portfolio is driven by a combination of agricultural, biological, and regulatory factors, such as national production planning policies. Furthermore, this strategy allows farmers to balance income and expense risks, contributing to more sustainable farm management (Anonymous 2023d).

The distribution of cattle numbers is shown in Table 4. The number of cattle by enterprise layer was recorded as 146 in Layer II, 87 in Layer III, and 577 in Layer IV. The number of cattle per enterprise ranged from 12 to 150, with an average of 38.57 cattle among those engaged in cattle farming. The highest concentration of cattle was observed in enterprises within Layer IV, accounting for 22.58% of the total cattle population. However, no statistically significant relationship was found between enterprise layers and the number of cattle (p=0.198).

Eleven dairy enterprises produced a combined total of 1 350 tons of milk annually, with individual production ranging from 50 to 240 tons. The average annual milk production per enterprise was calculated as 122.7 tons. Additionally, it was noted that one enterprise owned 20 lambs, while another specialized in lamb fattening with a total of 400 lambs.

Table 4. Distribution of Culture Breed Cattle by Enterprise Layer and Herd Size

Layers	Number of Culture Breed Cattle											Total Enterprises
	12	20	22	25	30	35	36	40	50	80	150	
II	-	-	-	-	1	-	1	-	-	1	-	3 (14.28%)
III	-	2	1	1	-	-	-	-	-	-	-	4 (19.04%)
IV	1	2	-	2	2	1	-	2	3	-	1	14 (66.16%)
Total	1	4	1	3	3	1	1	2	3	1	1	21 (100%)
$\chi 2$ =25.083; SD=20; P-değeri=0.198												

3.5. Distribution of tractors by brand and power levels

The survey determined in Eskil district identified a total of 184 tractors, with numbers ranging from 1 to 5 per farm. It was determined that 64.2% of the farms had two or more tractors, with an average of 1.74 tractors per farm. In comparative terms, 33.96% of farms in İzmir and only 3.5% in Erzurum are reported to own more than one tractor (Mavişoğlu Çobanoğlu 2019; Baybaş Aksoy 2021). The rate of farms with more than two tractors in the study area is relatively high. The ages of tractors in the tractor park range between 1 and 47 years, with an average tractor age of 5.45 years. It has been reported that the average tractor age in Turkey in 2018 was 24 years (Anonymous 2019; Ertekin et al. 2021). The survey results indicate that the proportion of tractors aged 25 years and older in the Eskil district is 2.72%. This suggests that the life of older tractors in Eskil is significantly lower than the national average. Considering the average economic lifespan of tractors is 15 years (Sabancı et al. 2003), only 4.35% of tractors in Eskil have exceeded their economic lifespan. Another

notable characteristic of the tractor park is that 75.54% of the tractors are in the 1-5 year age range. In Erzurum, the proportion of tractors within this age range has been reported to be 45% (Aksoy et al. 2019).

In the Eskil district tractor park, New Holland the great rate with a 44.57% share, followed by Massey Ferguson at 19.02% and Tümosan at 14.13%. John Deere and Erkunt follow with market shares of 5.43% and 4.89%, respectively, as shown in Figure 2. In comparison, the five most preferred tractor brands in Turkey as of August 2024 are New Holland (32.5%), Deutz (12.8%), Case (10.2%), Başak (8%), and Tümosan (7.3%) (Anonymous 2024b).

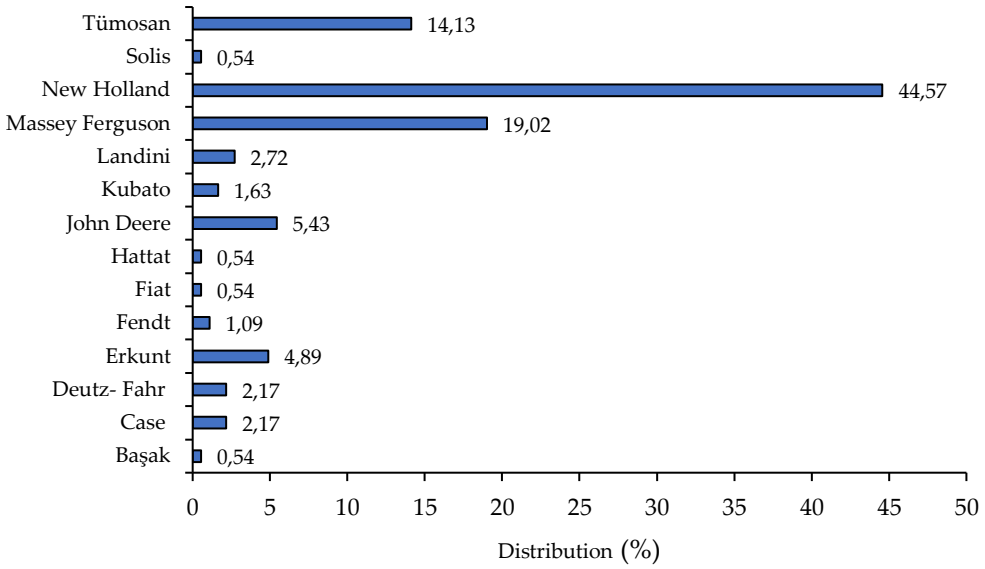

Figure 2. Distribution of Tractors by Brand

In the tractor park, the New Holland TD5.110 Bluemaster and New Holland TT65 models have the highest proportion, each accounting for 8.70%. The Massey Ferguson 5712M model follows with 5.43%, while the New Holland T6.135S accounts for 4.35%. Additionally, the New Holland T5.140 DC makes up 3.80%, and the New Holland TD5.100 Bluemaster represents 2.72% of the park. Following these models, the Massey Ferguson 5710M, Massey Ferguson 6S.135, New Holland TT75, and Tümosan 7065 tractors each hold a 2.17% share (Table 5). It has been determined that the tractors in the park belong to 68 different power groups, with power ratings ranging from 24.60 kW to 234.70 kW. The average tractor power in the park is 79.12 kW. Considering that the average tractor power in Turkey is 56.9 kW (Anonymous 2023c), it can be concluded that the average power value of tractors in the Eskil district is relatively high. Additionally, the total power value of the tractor park in Eskil has been calculated as 14 557.61 kW.

The distribution of tractors in the Eskil district by power groups is shown in Figure 3. The highest distribution is in the 70-79 kW power range, accounting for 17.65% of the park. This is followed by the 40-49 kW power range with 13.24%, and the 50-59 kW power range with 11.76%. The lowest proportions, at 1.47%, are observed in the 24.6-29 kW, 30-39 kW, 140-149 kW, 150-159 kW, 170-179 kW, and 234 kW+ power ranges. In Turkey, the largest tractor power range in the national park is reported to be 70-79 HP (52-60 kW), accounting for 20.6% of all tractors (Anonymous 2023c). However, in Eskil, the corresponding power range has been recorded at 10.39%, indicating a lower proportion compared to the national level.

The survey determined among the examined enterprises identified a total of three combine harvesters. Among them, one is in the third layer accounting for 4.17%, while two are in the fourth layer, making up 3.22%. Overall, 2.83% of the enterprises own a combine harvester. The combine harvesters in these enterprises include one 2015 model Fendt 5225 E and two 2013 model John Deere W540 machines.

Table 5. Distribution of Tractors by Brand and Engine Power

Tractor Brand	Number	Percentage (%)	Power (kW)	Total Power (kW)
Başak 2060	1	0.54	43.21	43.21
Case IH Puma 185 CVX	1	0.54	137.8	137.83
Case IH JX55E	1	0.54	41.0	40.98
Case IH JX75B	1	0.54	55.9	55.88
Case IH JX90	1	0.54	65.6	65.56
Deutz- Fahr 4100EF	1	0.54	76.0	75.99
Deutz-Fahr 5110G	1	0.54	82.0	81.95
Deutz-Fahr 6125C	1	0.54	93.1	93.13
Deutz-Fahr 6155.4	1	0.54	116.2	116.22
Erkunt Bereket 60E	1	0.54	44.7	44.70
Erkunt Bereket 65E	3	1.63	48.4	145.28
Erkunt Bereket 65M	2	1.09	50.7	101.32
Erkunt Haşmet 100 Lüks	1	0.54	74.5	74.50
Erkunt Haşmet 110 Lüks	1	0.54	82.0	81.95
Erkunt Haşmet 125 Lüks	1	0.54	93.1	93.13
Erkunt Kudret 105E+	1	0.54	76.0	75.99
Fendt 200 Vario	1	0.54	74.5	74.50
Fendt 500 Vario	1	0.54	107.3	107.28
Fiat 6056	1	0.54	41.7	41.72
Hattat 3055 DT	2	1.09	78.2	156.45
John Deere 5075E	1	0.54	122.9	122.93
John Deere 5105M	3	1.63	78.2	234.68
John Deere 6115MC	2	1.09	90.1	180.29
John Deere 6125R	1	0.54	160.2	160.18
John Deere 6155R	1	0.54	111.8	111.75
John Deere 6215R	1	0.54	160.2	160.18
John Deere 6310	1	0.54	82.0	81.95
Kubato M 7040	1	0.54	52.2	52.15
Kubato M 8540	1	0.54	63.3	63.33
Kubato M 9540	3	1.63	73.0	219.03
Landini Mistral 55	1	0.54	41.0	40.98
Massey Ferguson 135S	1	0.54	24.6	24.59
Massey Ferguson 240S	2	1.09	36.5	73.01
Massey Ferguson 2635	1	0.54	55.9	55.88
Massey Ferguson 288G	2	1.09	67.1	134.10
Massey Ferguson 3WF.85	1	0.54	63.3	63.33
Massey Ferguson 5710M	4	2.17	74.5	298.00
Massey Ferguson 5711M	2	1.09	82.0	163.90
Massey Ferguson 5712M	10	5.43	89.4	894.00
Massey Ferguson 5S.115	1	0.54	85.7	85.68
Massey Ferguson 5S.125	1	0.54	93.1	93.13
Massey Ferguson 6S.135	4	2.17	100.6	402.30
Massey Ferguson 7620	1	0.54	149.0	149.00
Massey Ferguson 7716S	1	0.54	119.2	119.20
Massey Ferguson 7S.165	2	1.09	122.9	245.85
Massey Ferguson 7S.180	1	0.54	134.1	134.10
Massey Ferguson 7S.210	1	0.54	156.5	156.45
New Holland 75-56S	1	0.54	55.9	55.88
New Holland TD5.100 BLM	5	2.72	74.5	372.50
New Holland TD5.110 BLM	16	8.70	82.0	1311.20
New Holland T5.120	1	0.54	89.4	89.40
New Holland T5.140 DC	7	3.80	104.3	730.10
New Holland T5060	1	0.54	79.0	78.97
New Holland TR6.135S	8	4.35	100.6	804.8
New Holland T7.230 AutoCommand	1	0.54	171.4	171.35
New Holland T7.165S	1	0.54	122.9	122.93
New Holland T7.315 HD AC	1	0.54	234.7	234.68
New Holland TR6.135S	8	4.35	100.6	804.60
New Holland TT55	5	2.72	41.0	204.88
New Holland TT65	16	8.70	48.4	774.80
New Holland TT75	4	2.17	55.9	223.50
New Holland TD90	7	3.80	67.1	469.35
Solis S90	1	0.54	67.1	67.05
Tümosan 7065	4	2.17	48.4	193.70
Tümosan 7075	3	1.63	55.9	167.63
Tümosan 8005	16	8.70	78.2	1251.60
Tümosan 8095	2	1.09	70.8	141.55
Tümosan 8180	1	0.54	59.6	59.60
Total	**184**	**100**	**-**	**14 557.61**

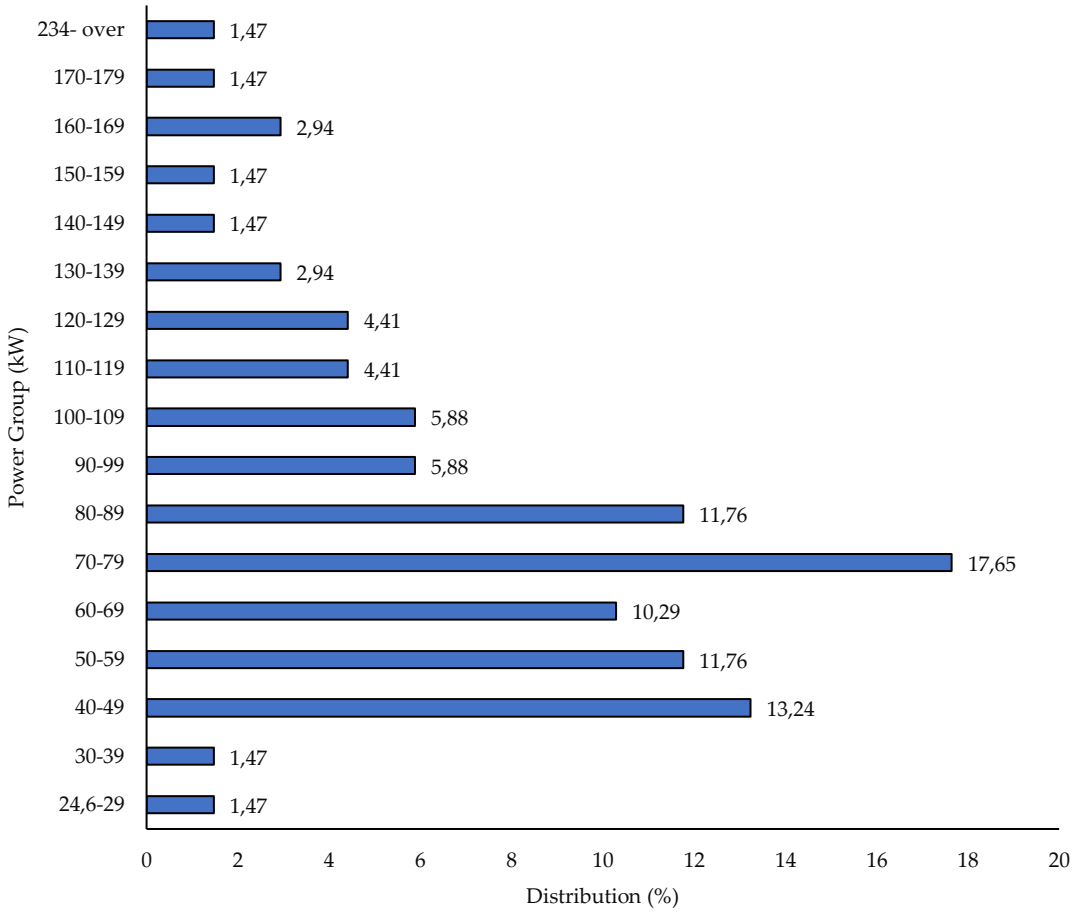

Figure 3. Distribution of Tractors by Power Groups

3.6. Annual Fuel Consumption

The annual fuel consumption values of agricultural enterprises are shown in Figure 4. When analyzing these values, it was observed that 8.5% of enterprises consume between 2 000 and 10 000 liters of fuel annually. According to the survey results, the annual fuel consumption of agricultural enterprises ranges from 350 liters to 39 000 liters, with a total fuel consumption of 851 750 liters. The average annual fuel consumption per enterprise was calculated as 8 035.38 liters. Based on the data evaluation, the fuel consumption per tractor was calculated as 4 629.08 liters per tractor, and the fuel consumption per cultivated area was determined as 174.82 liters per hectare. In comparison, a study reported by Keleş and Hacıseferoğulları (2016) in Çumra district of Konya found that the fuel consumption per tractor was 3 163.2 liters per tractor, and the fuel consumption per cultivated area was 220 liters per hectare. These findings indicate that while the fuel consumption per tractor in Eskil is higher than in Çumra, the fuel consumption per hectare is lower.

Table 6 shows the annual fuel consumption values of agricultural enterprises based on different layer. The average annual fuel consumption values for each layer were determined as 850 L, 32,200 L, 107,800 L, and 714,500 L, respectively. A statistically significant difference was found among the total annual fuel consumption values across the different layer ($p<0.01$). The average fuel consumption per enterprise in each layer was calculated as 425 L, 1 788.9 L, 4,491.7 L, and 11 524.2 L, respectively. The increase in total and per-enterprise average fuel consumption values across the layer is attributed to larger land sizes and greater production diversity.

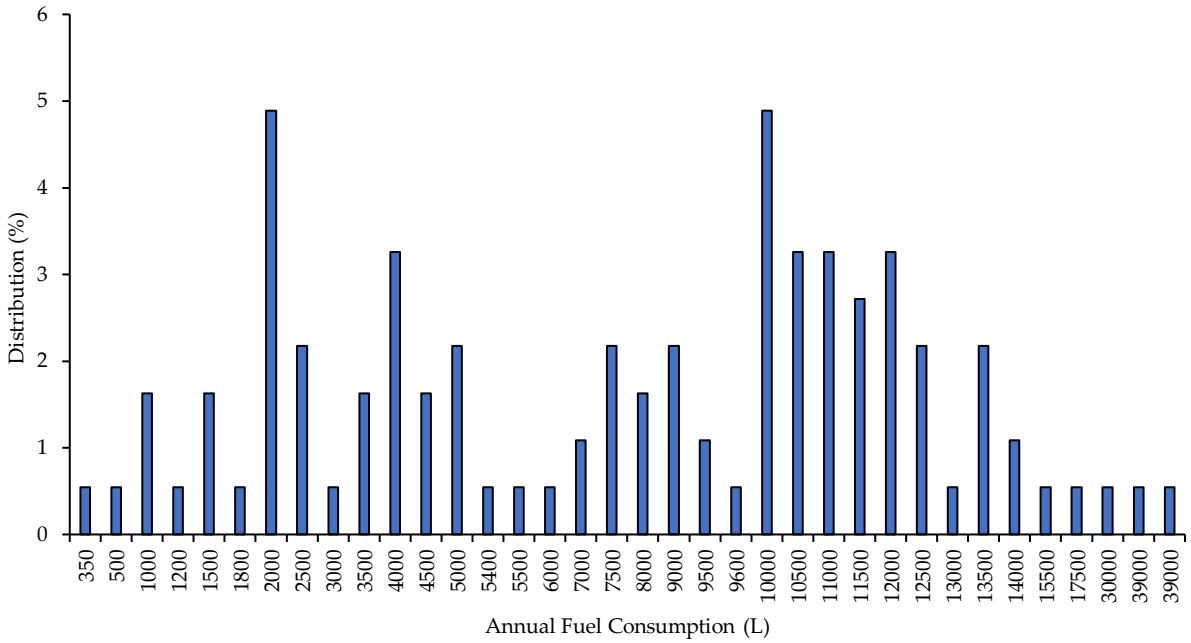

Figure 4. Annual Fuel Consumption of Agricultural Enterprises (L)

Table 6. Annual Fuel Consumption of Tractors

Layers	Annual Fuel Consumption		
	Total (L)	Average L (enterprises)$^{-1}$	Total
I	850	425	2
II	32 200	1 788.9	18
III	107 800	4 491.7	24
IV	714 500	11 524.2	62
Total	851750	-	106
χ^2 =298.546; SD=102; P-değeri=0.000			

3.7. Agricultural Machinery Park in Eskil District

The number and types of agricultural tools and machinery in agricultural enterprises and the average number of machines per farm and per tractor in Eskil district are shown in Table 7.

All machines belong to farmers and there are a total of 1 603 agricultural machines in the district. The machinery in the district is distributed as follows: 20.09% are deep well pumps, 11.23% are farm carts, 8.61% are plows, 7.36% are sprayers, 6.74% are combined drill/fertilizer mashine, and 6.30% are centrifugal broadcasters. Additionally, 5.99% of the machines are pneumatic precision drill, 4.30% are rollers, 4.00% are cultivator and cultivator rotary harrow combinations, and 3.87% are horizontal-vertical axis rotary tillers. Other machinery includes 2.18% corn forage harvesters, 1.75% rear loaders, 1.25% water tanker trailers and Feed Mixing Wagons, and 1.12% hay rakes. These represent the most commonly used types of agricultural machinery in the district.

The number of machines per tractor in Eskil district is as follows: trailer rank first with 0.98 units per tractor, followed by moldboard plows with 0.75 units, sprayers with 0.64 units, combined seed drills with 0.59 units, fertilizer broadcaster with 0.55 units, pneumatic precision seeders with 0.52 units, and rollers with 0.38 units. For comparison, in the Central Anatolia Region, the number of machines per tractor has been reported as 0.98 for trailer, 0.36 for sprayers, 0.37 for combined seed drill, and 0.25 for Centrifugal broadcasters (Ünsal 2021). These findings indicate that the number of machines per tractor in Eskil district is relatively high.

Table 7. Total Number and Weight of Machines in Agricultural Enterprises, and Number of Machines per Enterprise and Tractor

Agricultural Tools and Machines	Layers / Number Machines				Total Mumber	Machine (Tractor)$^{-1}$	Machine (Enterprise)$^{-1}$	Total Weight
	I	II	III	IV				
Moldboard Plow	2	18	26	92	138	0.75	1.30	131 760
Disc Plow	-	-	-	6	6	0.03	0.06	3 360
Subsoiler	-		6	26	32	0.18	0.30	16 327
Toothed Harrow	-	2	1	10	13	0.07	0.12	4 300
Disc Harrow	-	2	3	11	16	0.09	0.15	25 580
Centrifugal broadcasters	2	16	21	62	101	0.55	0.95	22 085
Rotary and Toot Harrow Combined Soil Preparation Machine	-	1	4	12	17	0.09	0.16	11 600
Combined drill/fertilizer machine	1	15	23	69	108	0.59	1.02	125 018
Sprayer	2	16	23	77	118	0.64	1.11	35 905
Cultivator and Cultivator + Rotary Harrow	-	8	16	40	64	0.35	0.60	59 996
Roller	-	5	14	50	69	0.38	0.65	46 190
Corn Forage Machine	-	5	5	25	35	0.19	0.33	39 700
Grass Silage Machine	-	-	1	6	7	0.04	0.07	4 340
Pneumatic spacing drills	1	16	12	67	96	0.52	0.91	101 185
Rotary cultivators with vertical axes	-	7	6	22	35	0.19	0.33	55 553
Rotary cultivators with horizontal axes	-	1	3	23	27	0.15	0.25	18 210
Straw Collecting Baler	-	1	-	-	1	0.005	0.009	1 590
Threshing Machine	-	-	-	1	1	0.005	0.009	1 500
Water tanker trailer	2	-	-	18	20	0.11	0.19	20 640
Trailer	2	18	34	126	180	0.98	1.70	330 150
Drum mowers	-	6	7	18	31	0.16	0.29	9 300
Disc movers	-	-	1	15	16	009	0.15	8 230
Bale collecting and stacking trailers	-	-	-	1	1	0.005	0.009	500
Feed Mixing Wagons	-	2	4	14	20	0.11	0.19	32 370
Rear loader	-	2	7	19	28	0.15	0.26	16 800
Reciprocating cutter bar	-	-	1	1	2	0.01	0.02	480
Pick-up balers	-	-	-	8	8	0.04	0.08	12 410
Fertilized Interrow Cultivato	-	1	8	16	25	0.14	0.24	29 018
Non-Fertilized Interrow Cultivator	-	-	1	-	1	0.005	0.009	700
Straw Chopper	-	-	1	-	1	0.005	0.009	750
Complete sugar beet harvester with hopper	-	-	1	6	7	0.04	0.07	23 700
Hay Rake	-	-	2	16	18	0.10	0.17	8 120
Heavy Disc Harrow	-	-	-	4	4	0.02	0.04	6 900
Feed Grinder*				9	9	0.05	0.08	2 600
Manure spreaders	-	-	-	3	3	0.02	0.03	12 140
Land Leveler Blade	-	-	-	4	4	0.02	0.04	850
Portable Milking Machine*	-	5	1	11	17	-	0.16	-
Milking systems design as a milking parlour	-	-	-	2	2	-	0.02	-
Deer well Pump*	-	30	58	234	322	-	3.03	-

* It has not been included in the number of machines per tractor in the calculations

In Eskil district, the survey results indicate that moldboard plows and traditional tillage systems are widely used due to the prevalence of grain production. As a result, the machinery number per enterprise is relatively high, with 1.30 moldboard plows, 1.02 Combined drill/fertilizer machine, 1.11 sprayers, 0.95 centrifugal fertilizer broadcaster, and 0.65 rollers per enterprise. In addition to traditional tillage, conservation tillage methods are also practiced in the region. It was determined that there are 0.33 vertical axis rotary tillers and 0.25 horizontal axis rotary tillers per enterprise, with a total of 62 units recorded in the district. For comparison, a study determined in Izmir found that the highest number of machines per enterprise were 0.81 trailers, 0.67 plows, 0.51 disc harrows, 0.47 cultivators, 0.34 sprayers, and 0.33 Centrifugal broadcasters (Mavioğlu and Çobanoğlu 2019).

The survey results indicate that each enterprise has an average of 3.03 deep well pumps, highlighting the intensive use of irrigation in the region. In addition, 21.70% of agricultural enterprises engage in both crop production and animal farming. As a result, these enterprises produce part of their feed needs, while some sell excess feed as an additional source of income. As a result, the number of forage-related machines per enterprise in the district has been determined as follows: 0.32 corn forage harvester, 0.29 drum mowers, 0.25 disc mowers, 0.17 hay rakes, and 0.19 feed mixing wagons. Additionally, based on the crop pattern of the district, there is an average of 0.17 sugar beet harvesters per enterprise. Excluding electrically powered

machines from the calculation, the number of machines per tractor was determined to be 6.80, while the number of tools and machines per enterprise was calculated as 15.12.

The status of the machines in terms of being new or second-hand and whether they are domestic manufactured or imported is shown in Table 8.

Table 8. Number and Percentage Distribution of Agricultural Tools and Machines by Situation and Origin

Agricultural Tools and Machines	New	Distribution (%)	Second-Hand	Distribution (%)	Domestic Production	Distribution (%)	Imported	Distribution (%)
Moldboard Plow	92	66.67	46	33.33	138	100	-	-
Disc Plow	4	66.67	2	33.33	6	100	-	-
Subsoiler	11	34.38	21	65.63	32	100	-	-
Toothed Harrow	5	38.46	8	61.54	13	100	-	-
Disc Harrow	3	18.75	13	81.25	15	93.75	1	6.25
Centrifugal broadcasters	56	55.45	45	44.55	101	100	-	-
Rotary and Toot Harrow Combined Soil Preparation Machine	7	41.18	10	58.82	17	100	-	-
Combined drill/fertilizer machine	88	81.48	20	18.52	106	98.15	2	1.85
Sprayer	76	64.41	42	35.59	115	97.46	3	2.54
Cultivator and Cultivator + Rotary Harrow	25	39.06	39	60.94	63	98.44	1	1.56
Roller	28	40.58	41	59.42	68	98.55	1	1.45
Corn Forage Machine	17	48.57	18	51.43	34	97.14	1	2.86
Grass Silage Machine	3	42.86	4	57.14	7	100	-	-
Pneumatic spacing drills	78	81.25	18	18.75	82	85.42	14	14.58
Rotary cultivators with vertical axes	20	74.07	7	25.93	27	100	-	-
Rotary cultivators with horizontal axes	25	71.43	10	28.57	30	85.71	5	14.29
Straw Collecting Baler	-	-	1	100	1	100	-	-
Threshing Machine	-	-	1	100	1	100	-	-
Water tanker trailer	4	20.00	16	80.00	20	100	-	-
Trailer	150	83.33	30	16.67	180	100	-	-
Drum mowers	18	58.06	13	41.94	31	100	-	-
Disc movers	13	81.25	3	18.75	16	100	-	-
Bale collecting and stacking trailers	1	100	-	-	1	100	-	-
Feed Mixing Wagons	20	100	-	-	20	100	-	-
Rear loader	22	78.57	6	21.43	28	100	-	-
Reciprocating cutter bar	2	100	-	-	2	100	-	-
Pick-up balers	8	100	-	0.00	8	100	-	-
Fertilized Interrow Cultivato	18	72.00	7	28.00	25	100	-	-
Non-Fertilized Interrow Cultivator	-	-	1	100	1	100	-	-
Straw Chopper	1	100	-	-	-	-	1	100
Complete sugar beet harvester with hopper	7	100	-	-	6	85.71	1	14.29
Hay Rake	11	61.11	7	38.89	18	100	-	-
Heavy Disc Harrow	3	75.00	1	25.00	4	100	-	-
Feed Grinder*	7	77.78	2	22.22	9	100	-	-
Manure spreaders	3	100	-	-	3	100	-	-
Land Leveler Blade	4	100	-	-	4	100	-	-
Portable Milking Machine*	17	100	-	-	16	94.12	1	5.88
Milking systems design as a milking parlour	322	100	-	-	322	100	-	-

In general, most machines, except those used for seedbed preparation, are purchased as new. Among tillage tools and machines, 81.25% of disc harrows, 65.63% of subsoilers, 61.54% of toothed harrows, 60.94% of cultivators and cultivator-rotary harrow combinations, 59.42% of rollers, and 58.82% of rotary and toodle combined harrow machines were found to be acquired second-hand. Additionally, 51.43% of corn forage harvesters, 41.94% of drum mowers, and 38.89% of hay rakes were found to be acquired as second-hand equipment. It has been determined that 14.58% of pneumatic precision drills, 14.29% of vertical-axis rotary tillers and sugar beet harvesters, 6.25% of disc harrows, and the single stalk chopper machine in the park are imported.

3.8. Level of Agricultural Mechanization

The mechanization values calculated using data obtained from the surveyed enterprises in Eskil district are shown in Table 9. Upon examining Table 9, it is observed that the agricultural land per enterprise is 459.62 da, the number of parcels is 3.44, and the average parcel size is 133.48 da. Although these values are higher than the national averages, the fragmented land ownership model is also evident in Eskil district. It is a fact that this situation has negative consequences on agricultural management and productivity.

The average age of tractors was determined to be 5.5 years, indicating that the tractor park in the region is relatively modern. On average, there are 1.74 tractors per enterprise, and the average engine power per tractor was calculated as 79.12 kW. The total tractor power per enterprise amounted to 137.34 kW, while the tractor power per unit of cultivated land was determine as 2.99 kW ha^{-1}.

Enterprises possessed an average of 15.12 implements and machines, while the number of implements per tractor was 6.80. The average implement-machine weight per tractor was found to be 6.07 tons, suggesting a preference for high-capacity equipment.

Table 9. Agricultural Mechanization Level Indicators of Eskil District

Level of Mechanization	**Value**
Number of enterprises	106
Agricultural land per enterprise (area (da)·enterprise^{-1})	459.62
Number of parcels per enterprise	3.44
Average parcel size (da)	133.48
Number of tractors	184
Average tractor age (years)	5.5
Average tractor power (kW)	79.12
Number of tractors per enterprise (tractor·enterprise^{-1})	1.74
Number of and machines per enterprise (machine·enterprise^{-1})	15.12*
Power per enterprise (kW·enterprise^{-1})	137.34
Tractor power per cultivated area (kW·ha^{-1})	2.99
Number of machines per tractor (machine·tractor^{-1})	6.80**
Cultivated area per tractor (ha·tractor^{-1})	26.48
Machine Weight per tractor (ton·tractor^{-1})	6.07**
Number of tractors per 1 000 ha of cultivated land	37.76
Number of combine harvesters per 1 000 ha of cultivated land	0.62

According to the Turkey Agricultural Machinery Sector Report, the average tractor power is reported as 40.2 kW, while the average tractor age is 24.4 years. Additionally, the number of tractors per 1 000 hectares is 52.5, the agricultural land per tractor is 19 hectares, and the tractor power per hectare is 2.1 kW (Anonymous 2019). When these values are compared with those obtained in Eskil district, it is observed that the average tractor age is approximately 4.5 times lower, the average tractor power is 2.1 times higher, the number of tractors per 1 000 hectares is lower, and the tractor power per hectare is higher.

In the Central Anatolia Region, the agricultural mechanization levels for the provinces of Kayseri, Kırşehir, Nevşehir, Niğde, Sivas, Yozgat, Aksaray, and Kırıkkale have been determined as follows: the average tractor power is 40.38 kW, the tractor power per unit agricultural area is 2.18 kW ha^{-1}, the number of tractors per 1 000 hectares is 53.90, the cultivated area per tractor is 18.55 hectares, and the number of combine harvesters per 1 000 hectares is 1.34 (Sağlam and Kuş 2016).

When comparing Eskil district with the Central Anatolia Region, it can be observed that Eskil has higher values for average tractor power, agricultural land per tractor, and the number of agricultural machines per tractor. However, the number of tractors per 1 000 hectares and the number of combined harvesters per 1 000 hectares are lower in Eskil. Additionally, according to Anonymous (2015), the number of implements and machines per tractor in Turkey is reported as 5.2 number, with an average machine weight of 4.2 tons. In Çumra district, these values are 13.54 number and 10.77 tons, respectively (Keleş and Hacıseferoğulları 2016). For Konya province, the reported values are 7.05 number and 5.57 tons (Oğuz et al. 2017).

4. Conclusions

This study aimed to determine the mechanization level of the Eskil district and to establish a baseline to support future agricultural investment planning. The collected data should be updated periodically to effectively evaluate agricultural production and contribute to the development of the local economy. The research was conducted during the post-COVID-19 recovery period, a time when Turkey's agricultural markets showed signs of economic optimism. Following the year 2020, the agricultural sector in Turkey experienced relatively favorable economic conditions. Several factors—such as high market prices for agricultural products, cash-based payment systems, improved access to credit, low interest rates, and advantageous exchange rates-contributed to enhanced financial stability among farmers. These positive trends were reflected in the agricultural machinery and tractor park of Eskil. The low average age of the tractors and the relatively high engine power indicate a modern tractor park. Favorable exchange rates particularly encouraged the purchase of imported tractors with engine powers exceeding 100 kW, increasing their prevalence within the region's machinery park. Although Turkey's agricultural machinery park is commonly considered old (Evcim et al. 2015), for PTO-driven equipment, working hours are often more relevant than age. Therefore, further research is needed on both machinery age and usage value to obtain a more accurate assessment. The survey also revealed a very low number of manure spreaders per farm or per tractor, underscoring the need to promote manure use and offer relevant farmer training programs. In the region, irrigation is commonly carried out using deep-well pumps. Given the impact of energy costs, motor power, and operational duration, improving pump efficiency could lead to significant water savings and reduced operating expenses. Promoting the adoption of modern irrigation systems could further enhance water resource management and support sustainable agricultural planning.

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