Turkish Journal of Agriculture - Food Science and Technology, 9(8): 1384-1389, 2021
DOI: https://doi.org/10.24925/turjaf.v9i8.1384-1389.4232

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

A GIS- Based Approach on Annual Tractor Use, Soil Type and Crop Pattern Interactions in Some Provinces of the Aegean Region[#]

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ARTICLE INFO

[#]*This paper is extracted from the PhD dissertation of the first author*

Research Article

Received : 29/01/2021
Accepted : 24/04/2021

Keywords:
Tractor power
Land use
Crop production
Great soil types
Farming systems

ABSTRACT

The objective of this study was to provide the basic data related to the tractor such as power ratios and annual use along with the production pattern, type of farms, farm size and their fragmentation, soil properties. In order to meet the above objective a survey study was conducted in 2013 in four provinces of the Aegean region namely Aydın, Denizli, İzmir and Manisa.Using a GPS device, the coordinates of the location of the agricultural lands were also found in order to analyze the data for further evaluation and GeoMedia Professional 6.0 CBS software. The results from the study indicated that the annual use of tractors is about 650 hours and the surveyed land is a typical example and resembles the whole country in terms of average land size and fragmented land structure. The total land owned by 305 farmers was calculated to be 4023.1 ha and each farmer has 7.47 ha land. On the other hand, the average parcel size was found to be 0.86 ha. The distance between the parcels ranged between 0.5-10 km mostly while %12 of the lands was out of this range.

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Introduction

Agricultural production is of importance for Turkey and it has a high agricultural potential. In order to use this potential efficiently the level of mechanization must be elevated. The most important indicator to determine the level of mechanization is about tractor use in agricultural operations. In this perspective, it is important to examine the tractor related parameters such as power, age and annual use (Ozgunaltay Ertugrul et al., 2019).

Saglam and Demir (2002) conducted a study in North West in the north west Turkey and they found that the annual tractor use was 482 and 467 hours for dry and dry/irrigated farming, respectively. Not only tractor related parameters but also crop pattern and land fragmentation are of importance from the point of agricultural operations (Degirmecioglu et al., 2019). In order to use inputs efficiently and doing farming on timely manner, and for a better management of farmlands, tractor power and use of machinery is of importance and they determine level of mechanization in a certain country (Evcim el al., 2012).

The Agricultural Mechanization phenomenon consists of the machine and tool utilization for different farming operations, preparation for storage and on-farm processing and it includes three main power source groups: humans, animals, and machines (Rijk, 2013).

The selection of tractor in a certain power depends upon many factors and could be related to the land use, the size of the land, the crop grown and the soil type. On the other hand, farmer's preferences also play an important role for purchasing a tractor. The data to be obtained from the farmers will help mechanization planning for a basin or province base, as well as the country level. Geographical Information Systems (GIS) increase the efficiency of interrelation analyses of such factors by providing capability to create complex databases (Sarı, 2019; Arıcak, 2020). The annual use of tractors is one of the important parameters (Evcim and Ertuğrul, 2017). In this sense, the objective of this study was to determine the plant production and use of tractor relations and create a dynamic database that can be improved and further developed using GIS as in the example of the Aegean Region. It is believed that such a database to be created that includes the annual use of tractors, size of farms, production pattern and mechanization level will make recommendations and strategies regarding effective use and the tractor renewal decision possible.

Materials and Methods

The study was carried out in five stages as given below respectively,

- Creating the base map in GIS to decide the format and coordinate system of data used in database, to enter the provided data as layers such as updated satellite views and soil maps and digitalizing all data (Ozgunaltay-Ertugrul et al., 2019; Dartar, 2007).
- Preparation of survey, to determine the questions and evaluating method (Ozgunaltay-Ertugrul et al., 2019).
- Field work: to prepare the questionnaire and to determine the production pattern, coordinate information on testing provinces by the help of GPS and processing on the base map (Ozgunaltay-Ertugrul et al., 2019).
- Classification of production patterns according to the size of cultivated land-sown in towns by help of satellite views and data provided from Ministry of Food, Agriculture and Livestock (Ozgunaltay-Ertugrul et al., 2019; Dartar, 2007).
- Evaluation of survey results and processing the data.

In order to obtain data about the tractors in survey study, a stratified sampling was used to determine the sample size. As a probability technique the stratified sampling is to be done by dividing the entire targeted population into different sub-groups, and then randomized proportional selection of the final subjects from the different strata. This type of sampling can be used highlighting specific sub-groups within the population is necessary (Crossman, 2020). As a result of applying stratified sampling, a survey study with 305 tractor owners out of 1484 was conducted. The tractor owner's information database of the private tractor manufacturing company was used.

The study was carried out in the provinces of Aydin, Denizli, İzmir and Manisa as shown in Figure 1 and the number of the survey study by Provinces as a result of stratified sampling method is tabulated in Table 1.

Table 1. The calculated sample volume for different power group of tractors calculated by proportionate stratified sampling method with a probability level of %95.

Province	Tractor power groups														Total
	50	**	55	**	60	**	65	**	75	**	85	**	95	**	
Aydin	14	3	45	9	2	0	7	1	2	0	1	0	0	0	13
Denizli	19	4	18	4	4	1	16	3	1	0	4	1	0	0	13
İzmir	74	15	21	4	0	0	19	4	10	2	9	2	0	0	27
Manisa	304	63	572	118	39	8	233	48	37	8	15	3	18	4	252
	411	85	656	135	45	9	275	56	50	10	29	6	18	4	305
	1st Layer				2nd Layer						3rd Layer				
	0.39		0.61		0.14		0.86		0.52		0.30		0.19		
NS	85		135	220	9		56	65	10		6		4	20	305

NS: Number of surveys, ** Calculated number of surveys for different power groups

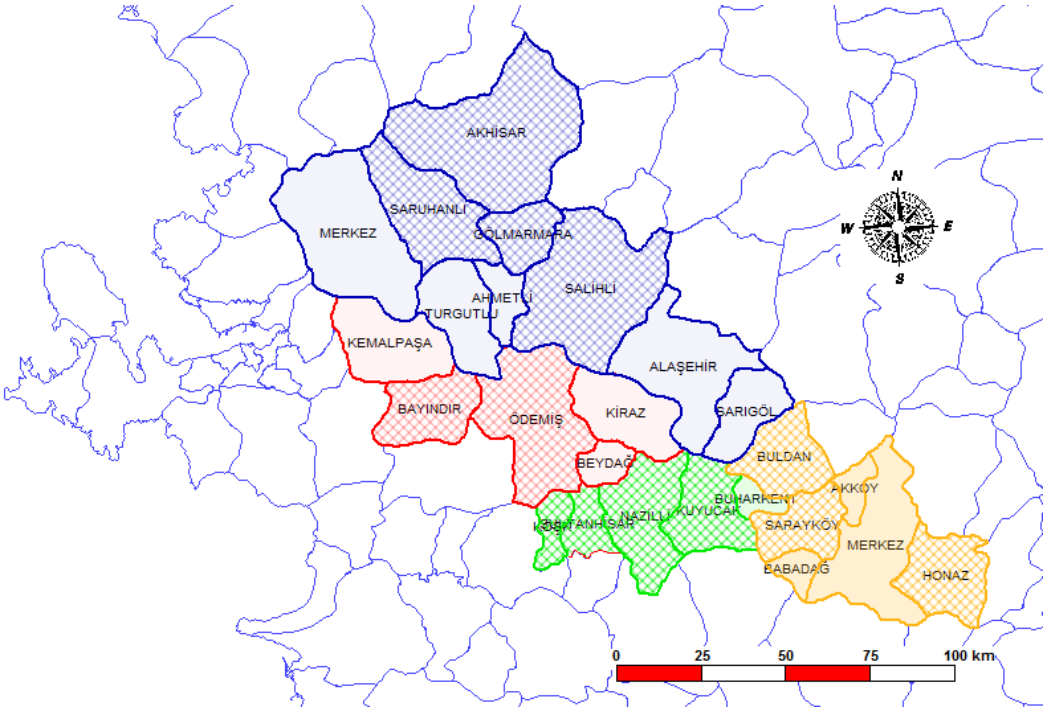

Figure 1. Boundaries of the surveyed area

Surveyed towns of Manisa, Unsurveyed towns of Manisa, Surveyed towns of İzmir, Unsurveyed towns of İzmir, Sureyed towns of Denizli, Unsurveyed towns of Denizli, Surveyed towns of Aydın, Unsurveyed towns of Aydın

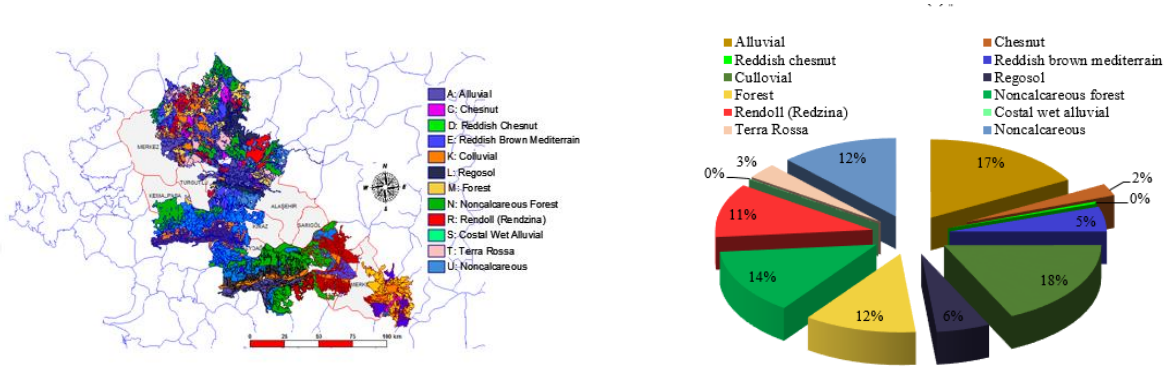

Figure 2. Distribution (a) and shares (b) of the great soil groups in the surveyed lands of the surveyed area

Aster and RapidEye satellite views were obtained from the Remote Sensing Laboratory of Department of Soil Science and Plant Nutrition, Faculty of Agriculture, Ege University to identify the great soil groups as shown in Figure 2. To create a dynamic database according to the rules of GIS, GeoMedia Professional 6.1 GIS software was used for this purpose. As seen from Figure 2, there are two largest soil groups distinguished in the surveyed land, namely, alluvial and colluvial soils. Reddish chestnut, forest and non-calcareous soils follow them.

Survey included;

- Model and power group of tractors
- Purchase date of tractors,
- Beginning date that the tractors were started to use
- Operations that tractors involved
- Crop production patterns
- Odometer values for the determination of tractors' running time
- Location and soil type of the landwhere the farming operations were carried out by tractors

Soil type, tractor use, crop pattern and land fragmentation were created as different layers in the database for further analysis and queries as depicted in Figure 3.

The data obtained from the survey study was compiled in an excel file and necessary filtration process was applied for further analysis in GeoMedia Professional 6.1 GIS software.

Results and Discussion

This study, aims to determine the relations of plant production and tractor use and to create a dynamic GIS based database that can be improved as in the example of the Aegean Region.

Dartar (2007) investigated the selected agricultural mechanization level values and mapped for provinces using GIS and transformed into a database for Turkey. It is stated that it is very important to compare the agricultural mechanization level, provided that it is associated with productivity for enterprises competing in similar production areas on the basis of accepted criteria. Consequently, according to the most common comparison criteria as kw ha^{-1},(Yılmaz and Sümer, 2018), Turkey's average tractor power per hectare level is determined to be 1.65 $kw.ha^{-1}$ at 2001, in comparison of the regions, Marmara region is with the highest value of 3.3 kw ha^{-1} and the Southeastern Anatolia region has the lowest value with 0.7 $kW.ha^{-1}$ (Dartar, 2007). Ozgunaltay-Ertugrul et al. (2019) created a GIS database by obtaining parameters related to tractor use and agricultural tools-machines in the Kırşehir region which is a much smaller area in comparison to Gediz Basin. Although they investigated main mechanization level criteria the annual tractor use was not studied. Nevertheless, they stated that the assessments of criteria belonging to present agricultural mechanization levels provide qualified scientific support to decision-makers for policy making to improve the farming systems of the region.

The number of the parcels owned by 305 farmers whose ages ranging between 24 and 75 were found to be 2950. The number of parcels owned by the farmers ranged between 1 and 25 as shown in Figure 4. The land fragmentation also known as pulverization is one of the well-known realities (Bentley, 1987; Yaslioglu et al, 2009; Kusek, 2014) of the Turkish farming. This situation was also confirmed by this study as seen from Figure 4. This means that a farmer has numerous discrete lands scattered over a wide area. As seen from the figure, number of parcels mostly accumulated on 4 and 13, the other parcels are mostly owned equally by the other farmers.

The total land owned by 305 farmers was calculated to be 4023.1 ha and each farmer has 7.47 ha land. On the other hand, the average parcel size was found to be 0.86 ha. The distance between the parcels ranged between 0.5-10 km mostly while %12 of the lands was out of this range.

Beyond the landowner, the number of people from the family members engaged with farming ranged between 2 and 5 and the largest group of 4 had a share of 47%. This was followed by 3 with a share of 40%. The education level of the farmers was also questioned, and it was found that the share of primary, secondary and those who graduated from a university was 33, 59 and 8%, respectively. The farmers grow different crops in a wide range in the surveyed land as depicted in Figure 5. The basin offers a large range of agricultural products as shown in Figure 3 and the largest share belongs to olive and grape production.

The number of parcels and number of crops grown relationship is shown in figure 6. There seems to be a trend, as the number of parcels increase the number of crops grown also increases and the correlation between the two was found to be +0.66.

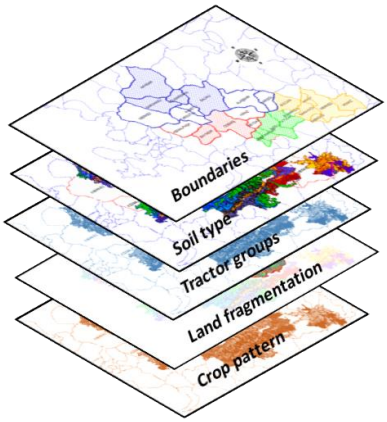

Figure 3. Layers considered in the GIS based study

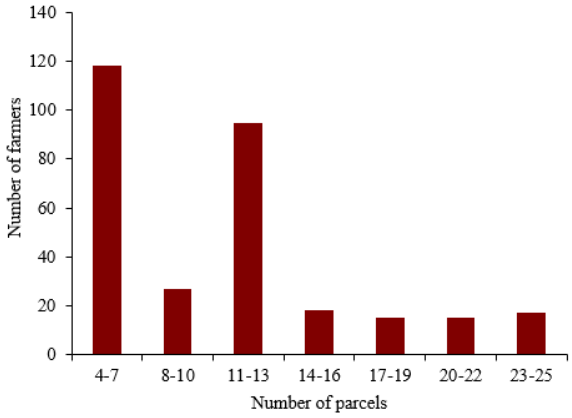

Figure 4. Relation of number of parcels and the number of farmers own the parcels

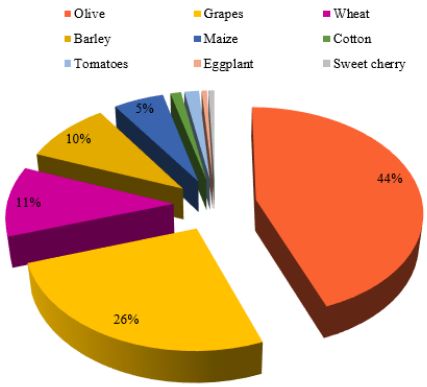

Figure 5. Shares of crops grown in the provinces

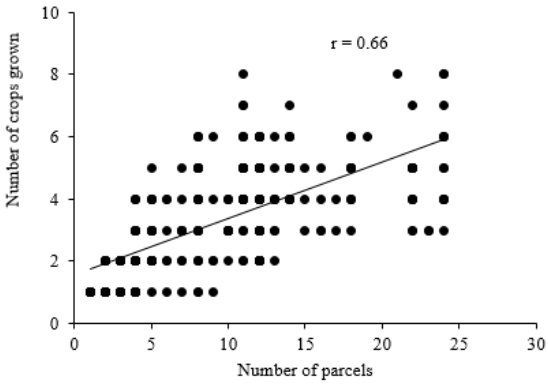

Figure 6. Number of parcels and number of crops grown in the surveyed area

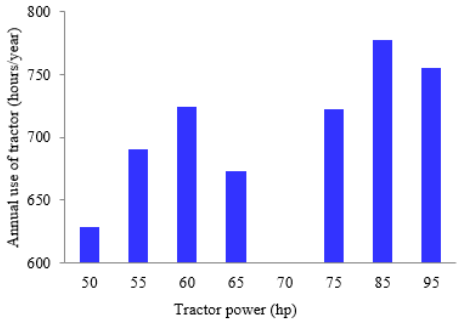

Figure 7. Tractor power groups and annual use of tractors

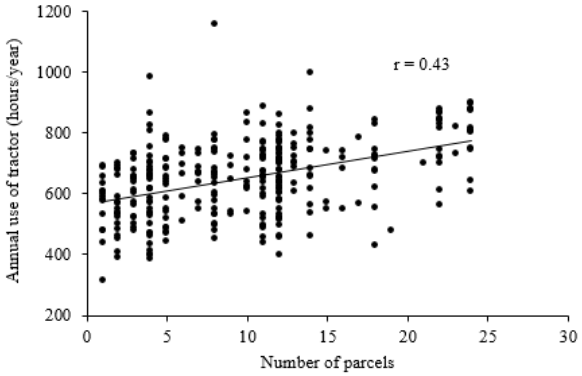

Figure 8. Number of parcels and annual use of tractors

The annual use of tractors and tractor power groups relation in the surveyed area is depicted in Figure 7. As seen from the figure, the annual use of he power group ranging between 50-65 Hp is lower than the power group of 75-95 hp.

From the above relation as shown in Figure 7, average annual use, standard deviation and a coefficient of variation in the surveyed area was calculated to be 649.9 hours, 7.1 and 19.1%, respectively. As seen from the figure, the annual use of 85 and 95 BG are higher than the other tractor groups.

Evcim and Özgünaltay (2017) studied annual tractor use based on the values of year 2010. They aimed to find out the tractor use in basin based. They found that the annual use of tractor was 443 hours and their study was conducted on 19396 tractors. In general, 50,55 and 65 HP tractors used generally 400 hours while 65 HP tractors were used 464 hours and tractors over 75 HP was used more than 500 hours. On the other hand, 85 HP tractors annual use was about 548 hours. The average annual traktor use value (649.9 h/year) is higher from the average annual tractor use of 365 h/year determined for the

Şanlıurfa-Harran region (Işık and Altun, 1998), the average annual tractor use of 377 h/year determined for Çanakkale (Sümer et al. 2008) and the average annual tractor use of 250 h/year time determined for Antalya (Akıncı and Çanakcı, 2000).

The annual use of tractors was also correlated with number of parcels in the surveyed area and this is depicted in figure 8. The correlation coefficient between the two was calculated to be 0.43.

Figure 9 depicts tractor power groups and annual use of tractors in different great soil groups as obtained from the GeoMedia Professional 6.0 CBS. As seen from the figure, 50 HP tractors are mostly used in Noncalcareous soil group (798 hours), while 55 HP tractors are run on regosol soils (726 hours). On the other hand 60 and 65 HP tractors are mostly used on Regosol and Noncalcareous forest soils, respectively as compared to other soil groups.

Figure 10 shows the distribution of parcels in the surveyed area. This is also good representative of land fragmentation in the surveyed area. As seen from the figure, the land is fragmented and distributed in a certain area.

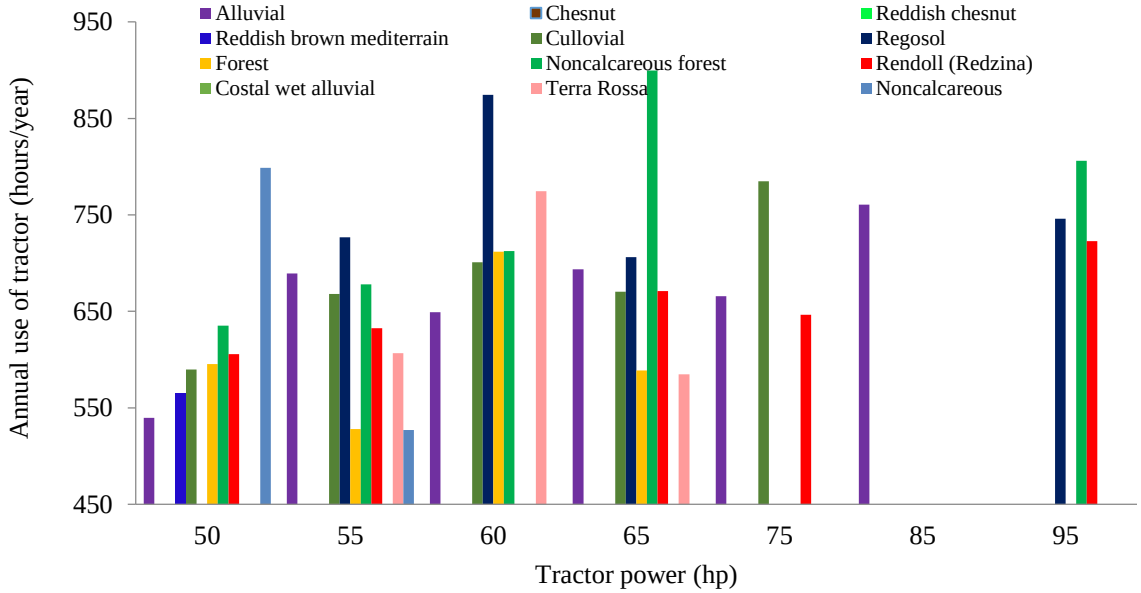

Figure 9. Tractor power groups and annual use of tractors in different great soil groups

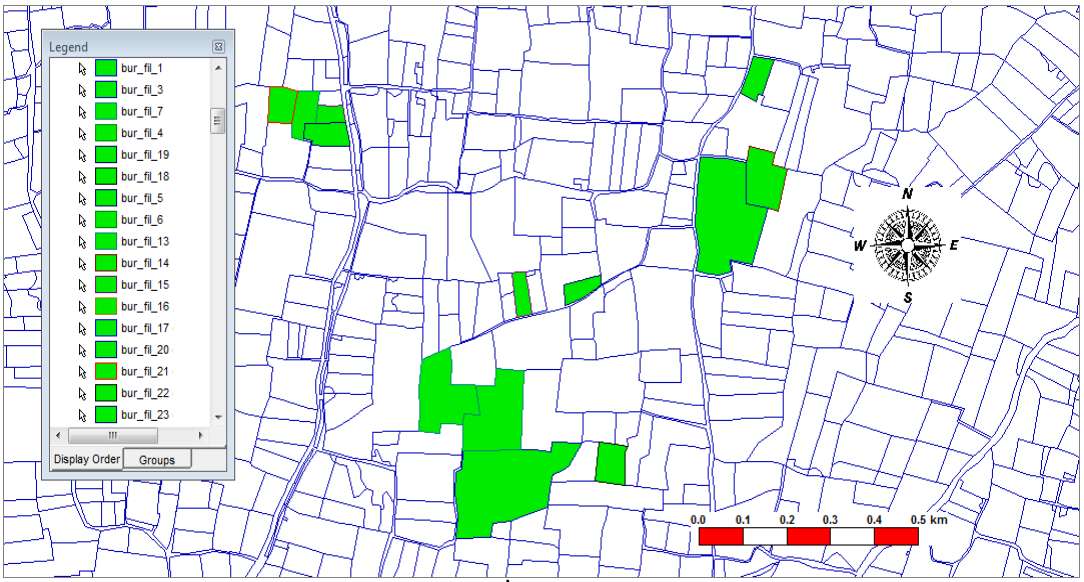

Figure 10. Distribution of parcels in theprovince of İzmir as a useof 85 HP tractor. (AlluvialandCullovialSoil)

Conclusions

There is no contemporary and dynamic database on annual use of tractors, crop pattern and mechanization level in the whole country and without such a dynamic database, to make recommendations and to develop strategies on renewal time, hourly and total cost of tractor use and mechanical/economical life of the tractor will not be possible. This is such a study that can be used as a master that could be applied to other provinces and basins or whole country in order to take necessary actions to elevate the mechanization level. It is believed that creating such a dynamic database and GIS will enable decision makers to produce better strategies.

The followings were concluded from the study conducted:

- This study confirmed the fragmented land use, a well-known reality of the Turkish farming system.
- The surveyed land is a typical example and resembles the whole country in terms of average land size and fragmented land structure.
- The tractor age ranged between 4 and 8 while the number of farmers who has second tractor was found to be 287 and these tractors were older than the ones they used, and the age of these tractors ranged between 12 and 22.
- The total land owned by 305 farmers was calculated to be 4023.1 ha and each farmer has 7.47 ha land. On the other hand, the average parcel size was found to be 0.86 ha. The distance between the parcels ranged between 0.5-10 km mostly while %12 of the lands was out of this range.
- Farming in the basin is also a typical example of business that is run by more than two people from the same family whose ages are ranging between 24 and 75.
- Annual use of tractors is about 650 hours and tractors are used in a wide range of farming operations to produce different crops in the provinces considered in this study. At this point it should be considered that the use of a tractor for a higher number of hours will increase the annual costs but lower hourly running costs.

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