Research Article

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Determination of Agricultural Machinery Usage Efficiency in Tokat Province Using Geographical Information Systems*

Coğrafi Bilgi Sistemleri Kullanılarak Tokat İlindeki Tarım Makinaları Kullanım Etkinliğinin Belirlenmesi

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Abstract: This study aimed to create a database on the presence of machinery on a district basis by mapping the utilization activities of agricultural tools and machinery used in the crops cultivated in Tokat and its districts and only in wheat agriculture with geographical information systems. In this context, the machines were divided into seven groups (Soil Tillage Machinery, Sowing and Planting Machinery, Maintenance and Fertilization Machinery, Plant Protection Machinery, Harvesting Machinery, Combine Harvester, and Tractors). The statistics on the cultivated areas and the number of machines on a district basis were obtained from the Turkish Statistical Institute. The calculated machine impact areas and planted areas were converted into circular areas and their radii were calculated. The calculated radii were converted into district-based maps with the help of ArcGIS 10.8 software. It was determined that there is a need for subsoilers, combi-harrow, stone collecting machinery, rotary cultivators, soil leveling machinery, rotary tiller, arc opening plough, seedling planting machinery, balers, and combine harvesters in Tokat. While the highest need was identified for balers, the highest surplus was identified for tractors. When the common crops and the machines commonly used in wheat agriculture are evaluated, it is concluded that production planning is important and planning should be made in accordance with the crop pattern.

Keywords: Agricultural machinery, machine ımpact area, geographical ınformation systems, effective working capacity

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Öz: Bu çalışmada Tokat ve ilçelerinde tarımı yapılan ürünlerde ve sadece buğday tarımında kullanılan tarım alet ve makinelerinin kullanım etkinlikleri coğrafi bilgi sistemleri ile haritalanarak belirlenmiştir. Bu kapsamda makineler 7 gruba (Toprak İşleme Alet/Makineleri, Ekim ve Dikim Makineleri, Bakım ve Gübreleme Makineleri, Bitki Koruma Makineleri, Hasat Makineleri, Biçerdöverler, Traktörler) ayrılmıştır. Türkiye İstatistik Kurumundan ilçe bazında ekilen alanlar ve makine sayıları alınmıştır. Makine etki alanları ile ekili alanlar, dairesel alana dönüştürülerek yarıçapları hesaplanmıştır. Hesaplanan yarıçaplar ArcGIS 10.8 programı yardımıyla ilçe bazında haritalara dönüştürülmüştür. Tokat genelinde dipkazan, kombikürüm, taş toplama makinesi, toprak frezesi, toprak tesviye makinesi, rototiller, ark açma pulluğu, fide dikme makinesi, balya makinesi ve biçerdöver ihtiyacı olduğu belirlenmiştir. En çok ihtiyaç balya makinesinde iken en çok ihtiyaç fazlalığı traktörde tespit edilmiştir. Yaygın tarımı yapılan ürünler ile buğday tarımında kullanılan makineler değerlendirildiğinde üretim planlamasının önemli olduğu ve ürün desenine göre planlamanın yapılması gerektiği sonucuna varılmıştır.

Anahtar Kelimeler: Tarım makineleri, makine etki alanı, coğrafi bilgi sistemi, efektif iş başarısı

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INTRODUCTION

To meet the needs of human nutrition, shelter, and clothing, it is essential to follow innovations in agriculture. Increasing agricultural productivity by enhancing yield per unit area significantly relies on the importance of advancing technology. The effective use of farm technologies in practices such as irrigation, fertilization, plant protection, and mechanization leads to an increase in productivity.

Agricultural mechanization involves conducting plant and animal production activities using power sources and machinery. Tasks that are not feasible with human and animal labor are accomplished through mechanization, allowing for production over larger areas, in shorter time frames, and with less labor. It minimizes the dependence of production activities on climatic and environmental conditions. Unlike other agricultural practices, agricultural mechanization indirectly affects yield increases. By enabling the use of new technologies, it enhances the effectiveness and cost-efficiency of technological applications and contributes to the improvement of working conditions (Özgüven et al., 2010).

Among the inputs used for agricultural production, mechanization represents a significantly high cost. If the farm owner selects equipment that is not suitable for the product group being cultivated or the size of the land, without considering local conditions, profitability will be adversely affected, potentially even leading to losses for the farm. Therefore, it is crucial to select appropriate machinery and make proper planning tailored to the farm's needs. The widespread adoption of mechanization can be achieved through this approach (Toğa, 2006).

When planning mechanization, using average data from very large areas can lead to significant errors. In this context, it is more accurate to evaluate smaller, homogenous areas rather than very large regions. Therefore, mechanization planning should be carried out at the levels of the enterprise, enterprise group, district, province, region, and country for a more realistic approach (Evcim, 1990).

The presence of surplus machinery in the agricultural enterprise, or the continuation of production activities with agricultural machinery that has completed its economic and mechanical lifespan, is an important cost factor that business owners often overlook. For effective agricultural production, it is crucial for the operator to maintain sufficient power in the enterprise and to have machinery within the economic lifespan suitable for this power (Yıldırım, 2019).

As in all industrial sectors, computer programs play a crucial role in advancing agriculture and effectively utilizing innovations. Geographic Information Systems (GIS), Remote Sensing (RS), and Global Positioning Systems (GPS) are used at various stages of agricultural production. These techniques are employed in soil tillage, planting, fertilization, spraying, and harvesting operations, as these applications directly affect productivity.

Geographic Information System (GIS) is a digital information system that enables the collection, storage, processing, and display of data to meet specific objectives (Uluğtekin and Bildirici, 1997). GIS accelerates information flow, facilitates effective and accurate analysis, enables easy data updating, and enhances productivity by saving labor and time (Uluğtekin and Bildirici, 1997). GIS, widely used today for its ability to make accurate and rapid decisions, is also extensively utilized in the field of agriculture.

In this study, the aim is to create a database at the district level regarding the machinery inventory status for the districts of Tokat. This will be achieved by considering the types of crops grown, the number of machines that have not reached their mechanical and economic lifespan, and the cultivated areas. The machinery coverage and cultivated areas will be mapped using GIS.

MATERIAL AND METHOD

Tokat province consists of 35.83% agricultural land, 12.12% meadow and pasture land, 44.12% forest land, and 7.93% other types of land (TSI, 2021).

In Tokat province, 62.4% of the areas used in agriculture consist of clay loam, 18.7% clay, 17.6% loam, 1% heavy clay, and 0.3% sandy types of soil (Tetik and Oğuz, 2004; Karaman, 2006).

Of the agricultural areas of Tokat province, 69.60% is arable agriculture, 4.78% is vegetable agriculture, 4.73% is fruit agriculture, 9.23% is other agricultural areas and 11.66% is vacant land suitable for agriculture (TSI, 2021). While field agriculture is at the forefront, it is also noteworthy that there is a high proportion of empty areas suitable for agriculture.

Considering the farmers registered in the Agricultural Information System and registered land assets, the number of enterprises and average enterprise sizes of the districts of Tokat are shown in the table. The average enterprise size in Tokat is 43 da (Table 1) (Anonymous, 2021).

Table 1. Number of enterprises and average enterprise sizes in Tokat districts
Çizelge 1. Tokat ilçelerindeki işletme sayıları ve ortalama işletme büyüklükleri

District	Number of Enterprises	Area (da)	Average Enterprise Sizes (da)
Almus	738	21.936	29
Artova	1.314	72.285	55
Başçiftlik	456	12.980	28
Erbaa	5.448	159.737	29
Merkez	5.841	211.497	36
Niksar	3.038	121.043	39
Pazar	1.616	54.614	33
Reşadiye	1.368	48.342	35
Sulusaray	1.325	64.339	48
Turhal	3.493	166.379	47
Yeşilyurt	978	57.809	59
Zile	6.059	389.500	64
Total	31.674	1.380.461	43

Classification of Agricultural Tools and Machinery

There are a total of 192.382 units of 76 different agricultural tools and machines in the Tokat center and districts. Within the scope of the study, agricultural tools and machines commonly used by enterprise owners in Tokat agriculture were evaluated. Agricultural tools and machines used in the whole province were categorized into 7 classes.

1. Soil Tillage Machinery (Mouldboard Plow, Disc Harrow, Toothed Harrow, Subsoiler, Combi Harrow, Cultivator, Roller, Stone Collecting Machinery, Soil Levelling Machinery, Rotary Cultivator, Rotary Tiller),

2. Sowing and Planting Machinery (Combined Seed Drill, Seedling Planting Machinery, Pneumatic Planting Machinery, Potato Planting Machinery),

3. Maintenance (Plant Care-Welfare Machinery) and Fertilization Machinery (Arc Opening Plough, Manure Spreading Machinery, Chemical Centrifugal Fertilizer Spreader, Tractor Drawn Hoeing Machinery),

4. Plant Protection Machinery (Field Crop Sprayer, Orchard Sprayer),

5. Harvesting Machinery (Baler, Corn Forage Harvester, Hay Rake, Sugar Beet Harvester, Potato Harvester, Tractor Drawn Mower),

6. Combine Harvester,

7. Tractors.

Calculation of Machine Impact Area

The machine impact area calculation for each agricultural machinery group was calculated with the help of equation (1) (Yıldız et al., 2007; Yıldırım, 2019).

$$A = F_{ef}\ x\ n\ x\ t\ x\ g \quad (1)$$

A : Machine impact area (da year^{-1})
F_{ef} : Effective working capacity (da h^{-1})
n : Number of machines (unit)
t : Daily working time (h day^{-1})
g : Number of annual workable days (days year^{-1})

Calculation of Machine Effective Working Capacity

Effective working capacity means real or ideal work success. It is calculated by adding the auxiliary time required for the completion of the task to the actual working time (Dinçer, 1970). The machine effective working capacity was calculated using equation (2).

$$F_{ef} = b\ x\ V\ x\ k \quad (2)$$

b : Machine working width (m)
V : Forward speed (km h^{-1})
k : Time-use coefficient (%)

In the Tokat region, the brands of commonly used agricultural machinery were identified, and the working widths specified in the company catalogues were used as data.
Machine forward speeds and time-use coefficients are provided in Table 2 (Özmerzi et al., 2004).

Table 2. Forward speeds and time-use coefficients of agricultural machinery
Çizelge 2. Tarım makinelerine ait ilerleme hızları ve zamandan yararlanma katsayıları

Agricultural Machinery	Effective Working Capacity (da h^{-1})	Working Width (m)	Forward Speed (km h^{-1})	k (%)
Mouldboard Plow	4.32	0.90	6	0.80
Disc Harrow	12.75	2.50	6	0.85
Toothed Harrow	16.20	2.25	9	0.80
Subsoiler	7.65	1.80	5	0.85
Combi Harrow	11.48	2.25	6	0.85
Cultivator	18.36	2.70	8	0.85
Roller	16.83	2.20	9	0.85
Arc Opening Plough	5.04	0.90	7	0.80
Stone Collecting Machinery	5.46	1.40	6	0.65
Soil Levelling Machiner	8.93	2.10	5	0.85
Rotary Cultivator	6.80	2.00	4	0.85
Rotary Tiller	7.44	1.75	5	0.85
Seedling Planting Machinery	3.90	2.00	3	0.65
Combined Seed Drill	12.60	2.25	8	0.70
Potato Planting Machinery	4.50	1.50	5	0.60
Pneumatic Planting Machiner	16.80	3.00	8	0.70

Table 2. Continue.

Çizelge 2. Devamı.

Agricultural Machinery	Effective Working Capacity (da h^{-1})	Working Width (m)	Forward Speed (km h^{-1})	k (%)
Manure Spreading Machinery	13.44	2.40	8	0.70
Chemical Centrifugal Fertilizer Spreader	84.00	14.00	8	0.75
Tractor Drawn Hoeing Machinery	14.00	2.50	7	0.80
Field Crop Sprayer	50.40	12.00	7	0.60
Orchard Sprayer	28.50	9.50	5	0.60
Baler	6.24	1.30	6	0.80
Corn Forage Harvester	4.06	1.25	5	0.65
Hay Rake	18.36	2.70	8	0.85
Sugar Beet Harvester Machinery	9.45	2.70	5	0.70
Potato Harvester	3.15	1.50	3	0.70
Tractor Drawn Mower	11.22	1.65	8	0.85
Combine Harvester	13.16	4.70	4	0.70

The tractor effective working capacity for each district was calculated by taking the arithmetic average of the effective working capacities of the machines in that district.

Number of Machines

The presence of agricultural machinery, planted, and harvested areas in Tokat province and its districts were obtained from the Turkish Statistical Institute (TSI) (TSI, 2021).

When the economic life of agricultural machinery is accepted as 10 years, it is considered that 50% of the machines have completed their economic life (Yıldırım, 2019). In this context, 50% of the machines in the machinery parks in Tokat and its districts in the class of tillage tools/machines, sowing and planting machines, maintenance and fertilization machines, plant protection machines, and harvesting machines were taken into consideration.

Combine harvesters generally use the contracting system. For this reason, the economic life of the harvesters in Tokat province was accepted as 10 years and included in the calculations (Yıldırım and Konak, 2019).

In Turkey, 43% of the existing tractor park has completed its economic life (Özgüven, et al., 2010). In this study, 57% of the tractors in Tokat and its districts were included in the study.

Data on Tillage, Sowing and Planting, Maintenance and Fertilisation, Plant Protection, Harvesting Machines, and Harvester and Tractor groups are taken from TSI (TSI, 2021).

Daily Working Time

In the calculation of the impact area of agricultural machinery, the daily working time was taken as 8 hours (Yıldız et al., 2007).

Number of Annual Workable Days

The number of workable days in agriculture is expressed as the number of days that any agricultural tool and machine can perform the desired task, that is, it can work in the field. In determining the number of workable days, the process was divided into three groups by considering the most time-consuming agricultural production activities: soil tillage, maintenance, and harvesting operations (Kuşçu, 2008).

The number of workable days was calculated based on the averages of daily average temperature, total precipitation, and soil temperature at a depth of 10 cm from 2010 to 2021, considering the criteria given by Kuşçu (2008). (MGM, 2021; Alan, 2023).

Planted Areas Used In Impact Area Calculation

Separate evaluations were made for all plants widely cultivated in Tokat province and wheat plant. These data were taken from (Alan, 2023).

In the calculation of machine impact area for machine classes based on Tokat and districts, calculations were made by determining the workable day interval by taking into account the operations carried out in the products widely cultivated and the tools and machines used for these operations.

For the wheat cultivated throughout the province of Tokat, the operations carried out and the workable day intervals for these operations were determined and the radius of the machine impact area radius and the planted area radius for the districts were determined and mapped with the help of the ArcGIS program.

Calculation of Planted Area and Machine Impact Area Radii

The impact areas (da) calculated according to equation (3) for each machine group were converted into circular areas on a district basis and the radius (m) of this area was calculated. In addition, according to the agricultural production pattern in each district, the planted areas were considered as a circle, and the radius of these areas was determined. The planted area radius and the machine impact area radius were calculated with the help of equation (3) (Yıldız et al., 2007).

$$r = \sqrt{A/\pi} \quad (3)$$

r : Planted area / Machine impact area radius (m)
A : Planted area / Machine impact area (m^2)

Calculation of the required number of machines

The required number of agricultural machinery/agricultural machinery group (*RNM*) was calculated by proportioning the areas of influence of the machines to the areas where tillage/planted/harvested was carried out (Yıldırım, 2019).

$$RNM = A/F_{ef} \quad (4)$$

Mapping With Geographic Information Systems

Geographical Information Systems (GIS) is a system that collects location-based data, can display these collected data, and has features that enable the combination of maps and tables. In this way, it provides statistical analyses with the help of maps and classification of information by using the database and plays an important role in planning (Yomralıoğlu, 2000; Akbaş et al., 2008; Başayiğit et al., 2008). Within the scope of this study, the mapping process with GIS consisted of 4 stages.

1. Creation of Tokat province map: The map downloaded from the General Directorate of Mapping was transferred to ArcGIS 10.8 program.

2. Preparation of database: The planted area and machine numbers of the districts of Tokat were taken from the Turkish Statistical Institute. The planted area and machine impact area radii were calculated and the database was created.

3. Making analyses based on position: Analyses were made for each district separately by taking into account the planted area and machine impact area radii and the number of machines.

4. Obtaining result maps: Maps were created for each machine group used in common crops. In the machinery groups used in wheat agriculture, maps were obtained for tillage tools/machines, fertilizing machines, and tractors.

RESULTS AND DISCUSSION

Soil Tillage Machinery

Maps of the cultivated area and machine impact area of Tokat districts are given in Figure 1. The total cultivated area in Tokat is 2.720.720 da and the cultivated area radius is 29.428 m. The total impact area of tillage tool/machines was calculated as 193.657.313 da and the impact area radius was 248.280 m. It was determined that the machine impact area is 70 times larger than the cultivated area in Tokat. The fact that the machine impact area is very large is due to the high number of mouldboard plows, toothed harrows, and cultivators. This value, which was found 2.6 times in the study conducted for Erzurum province (Yıldız et al., 2007) and 33 times in the study conducted for Konya (Yıldırım, 2019), shows that the trend is similar to our study. Among the districts of Tokat, the highest value was obtained in the Merkez district 120 times, and the lowest value was obtained in the Başçiftlik district 39 times. At the same time, in all districts, there are more machines than required as well as inadequate machines. Among the districts, Zile has the highest number of tillage tools/machines and Başçiftlik has the lowest number. While 27.240 machines are used throughout the province, 5.276 machines are considered sufficient. The unbalanced distribution of machinery in the province of Tokat, where field, vegetable, and fruit agriculture is intensively carried out, in other words, the fact that the number of machinery is more or less than it should be can be seen as a result of unplanned behavior.

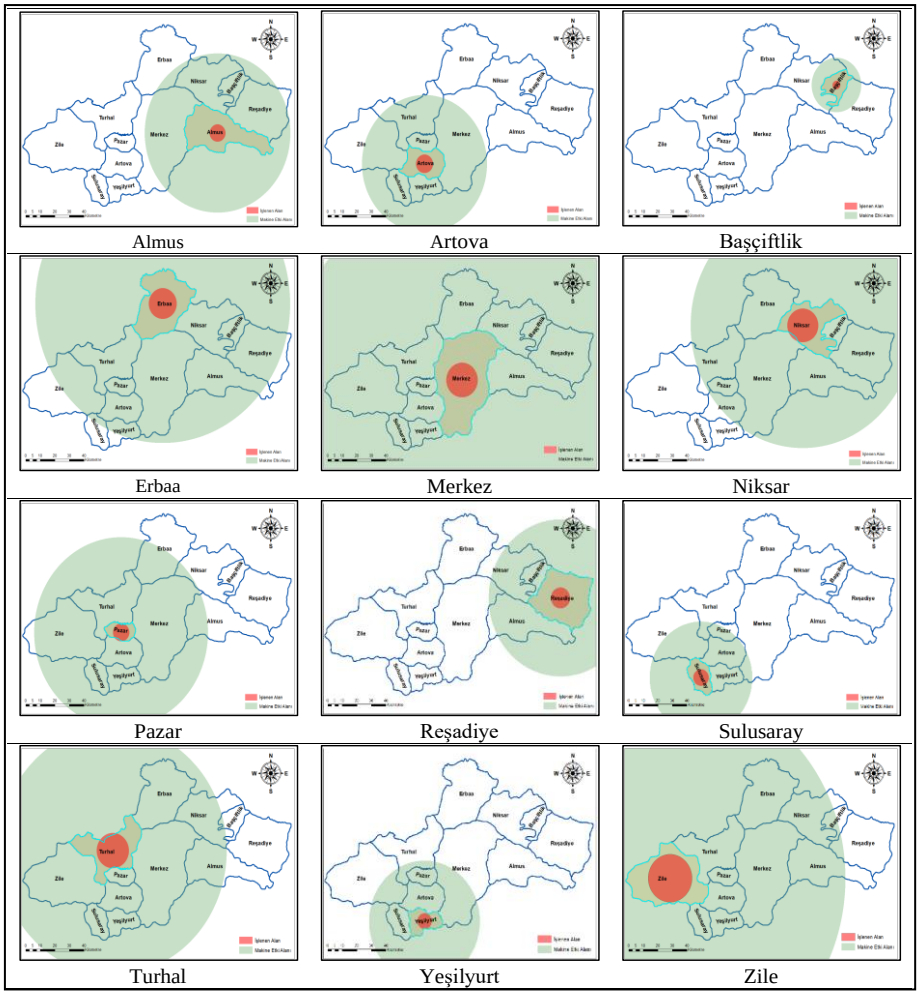

Figure 1. Maps of cultivated areas and machine impact areas in the districts of Tokat
Şekil 1. Tokat ilçelerinde işlenen alan ve makine etki alan haritaları

Sowing and Planting Machinery

The total planted area in the whole province is 2.467.235 da and the planted area radius is 28.024 m. The total sowing/planting machines impact area has been calculated as 4.279.843 da, with an impact area radius of 36.910 meters. It was determined that the machine impact area was approximately 2 times more than the

planted area in the whole province (Figure 2). Except for seedling planting machines, the surplus was determined in other machines. Among the districts, the highest number of sowing/planting machines is in Zile and the lowest number is in Başçiftlik district. While 872 machines are sufficient in total, 633 extra machines are used.

In the study conducted in Erzurum province, the sowing/planting machines impact area covered 60% of the cultivated area (Yıldız et al., 2007), whereas, in this study, it was found to affect 73% more area than the planted area. It can be said that mechanical sowing is more widespread in Tokat province.

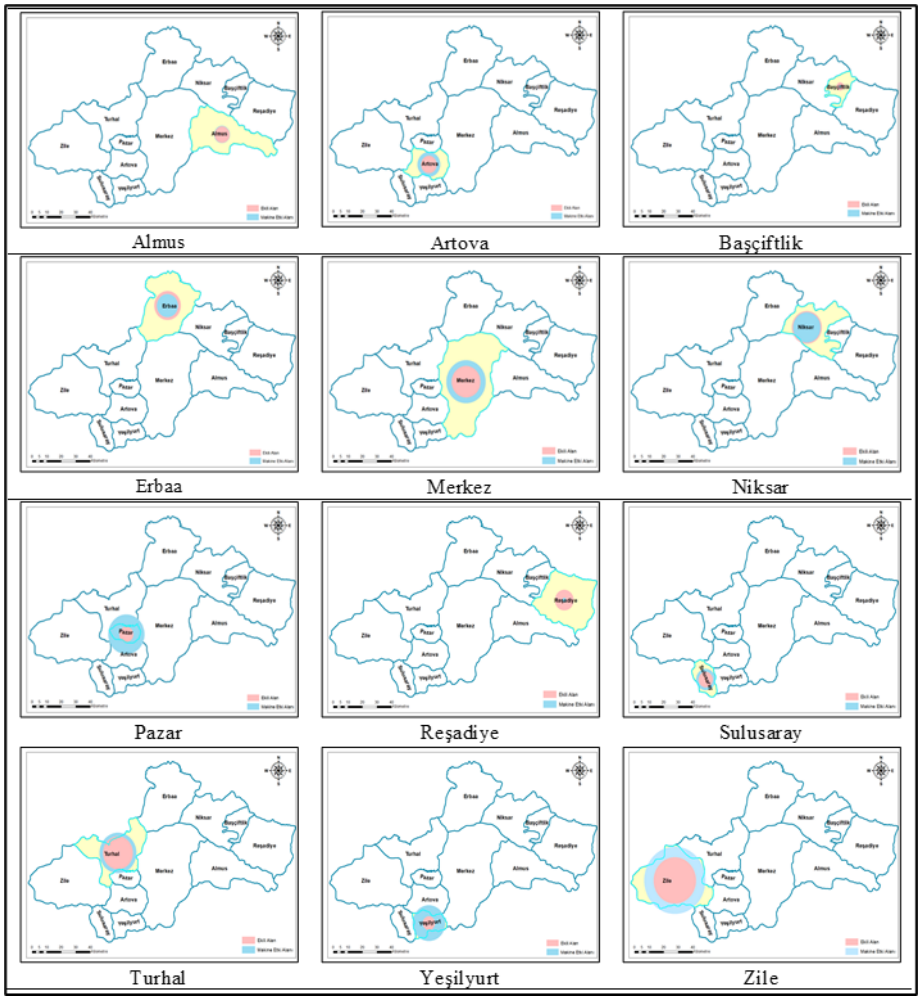

Figure 2. Maps of planted areas and machine impact areas in the districts of Tokat
Şekil 2. Tokat ilçelerinde ekili alan ve makine etki alan haritaları

Maintenance and Fertilization Machinery

Maintenance and fertilized area and machine impact area maps of Tokat districts are given in Figure 3. The total maintenance and fertilized area in Tokat is 2.893.670 da and the radius of the area is 30.349 m. The total maintenance and fertilization machines impact area is 122.079.548 da and the impact area radius is 197.127 m. It was determined that the machine impact area in the whole province is 41 times greater than the fertilized area. The reason for the high machine impact area is due to the chemical centrifugal fertilizer spreader. Among the districts of Tokat, this value is highest in the Pazar district with 122 times and lowest in the Başçiftlik district. In the study conducted in Konya province, it was determined that the highest need in the maintenance and fertilization machinery group was for the manure spreading machine (Yıldırım, 2019).

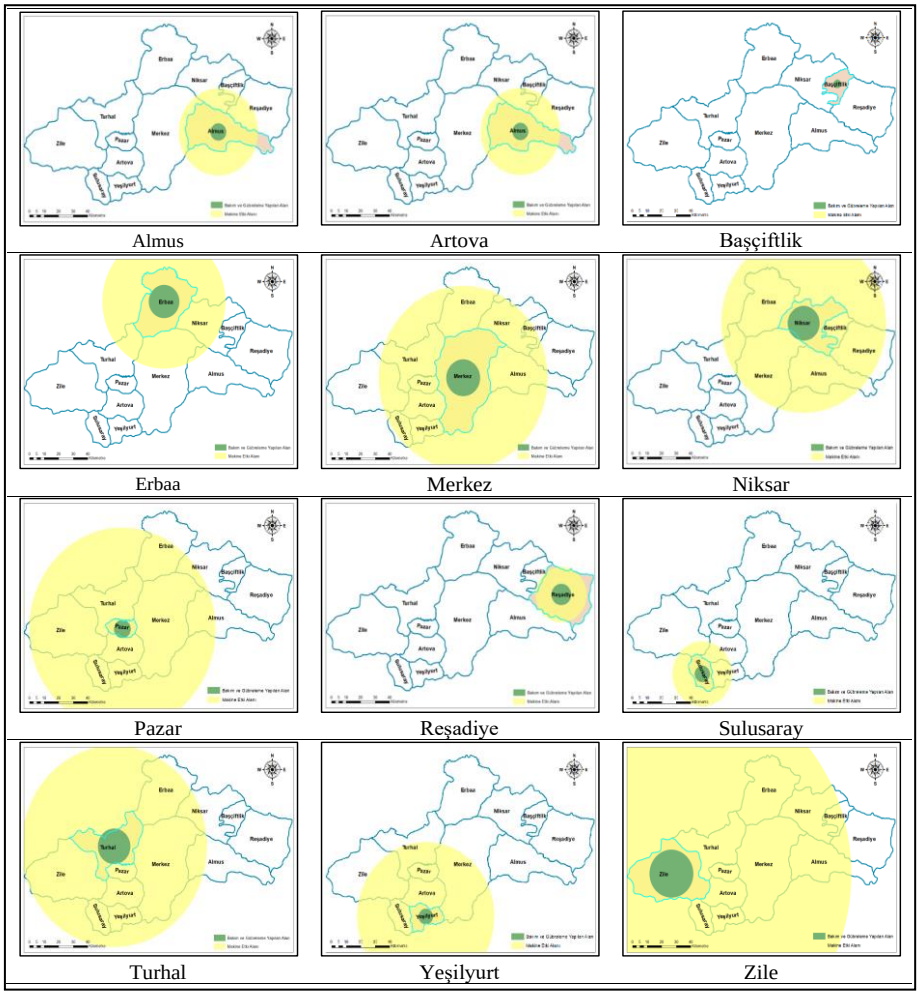

Figure 3. Maps of maintenance and fertilized areas and machine impact areas in the districts of Tokat
Şekil 3. Tokat ilçelerinde bakım ve gübreleme yapılan alan ve makine etki alan haritaları

Plant Protection Machinery

The sprayed area and machine impact area maps of Tokat districts are given in Figure 4. The total sprayed area in Tokat is 2.893.670 da and the sprayed area radius is 30.349 m. The plant protection machinery' total impact area is 44.194.255 da and the impact area radius is 118.606 m. In the whole province, It is calculated that the machine impact area is 14 times more than the sprayed area. Among the districts of Tokat, this value is highest in the Merkez district at 26 times and lowest in the Başçiftlik district.

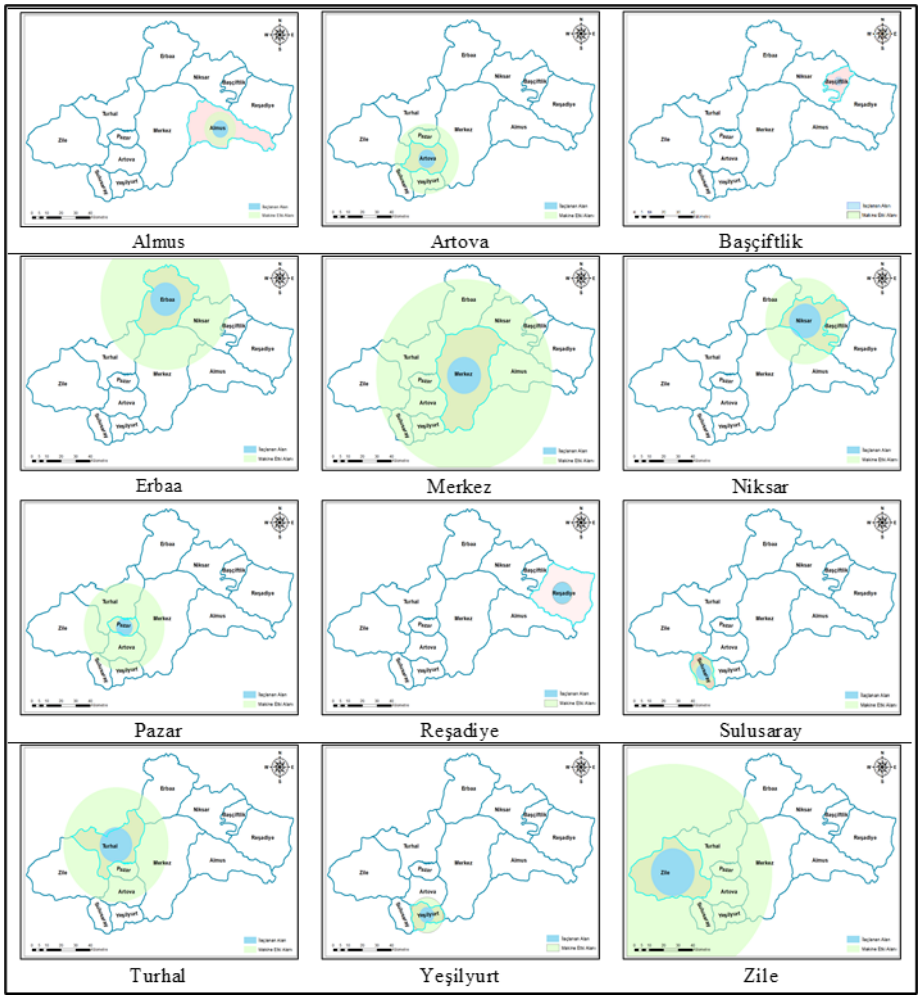

Figure 4. Maps of sprayed areas and machine impact areas in the districts of Tokat
Şekil 4. Tokat ilçelerinde ilaçlama yapılan alan ve makine etki alan haritaları

Harvesting Machinery

Harvested area and machine impact area maps of Tokat districts are given in Figure 5. The total harvested area in Tokat is 2.102.523 da and the harvested area radius is 25.870 m. The harvesting machinery' total impact area was calculated as 3.888.714 da and the impact area radius was 35.183 m. It was determined that the machine impact area in Tokat was 0.8 times smaller than the harvested area. Among the districts of Tokat, the highest value was obtained in the Pazar district with 13 times, and the lowest value was obtained in the Turhal district at 0.16 times.

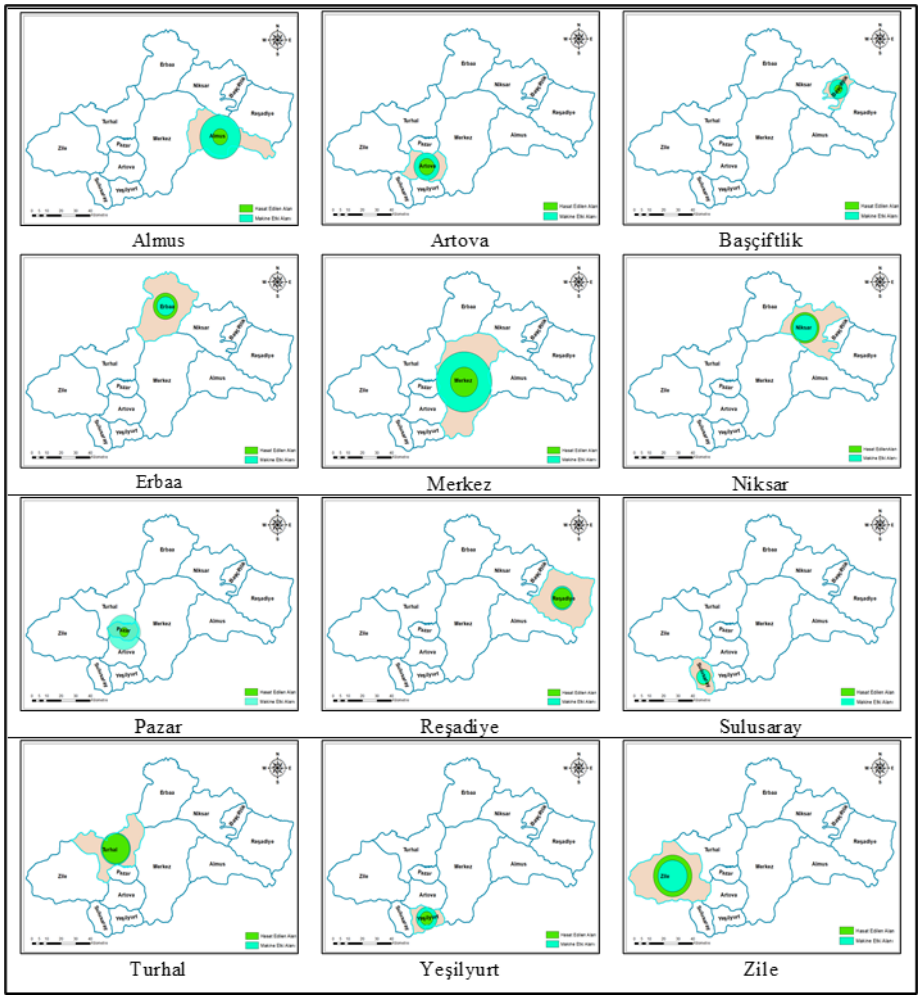

Figure 5. Maps of Harvested Areas and Machine Impact Areas in the Districts of Tokat
Şekil 5. Tokat ilçelerinde hasat edilen alan ve makine etki alan haritaları

Combine Harvester

The maps of harvested areas by combine harvesters and machine impact areas for the districts of Tokat are shown in Figure 6. The total harvested area by combine harvester in Tokat is 1.903.404 da and the harvested area radius is 24.614 m. The combine harvesters' total impact area is 760.332 da and the impact area radius is 15.557 m. It was determined that the machine (combine harvester) impact area was 0.39 times smaller than the harvested area in Tokat.

Almus, Başçiftlik, Niksar and Reşadiye districts have no harvester. Except for the Merkez district, it was determined that all other districts need combine harvesters. The districts with the highest need for combine harvesters are the Zile, Niksar, and Erbaa districts respectively. While there were 124 combine harvesters in Tokat, it was determined that there was a need for 209 more combine harvesters. The need for combine harvesters during the season is met by the contracting system with combine harvesters coming from other provinces. In the study conducted in Konya province, results with a similar trend were obtained (Yıldırım, 2019).

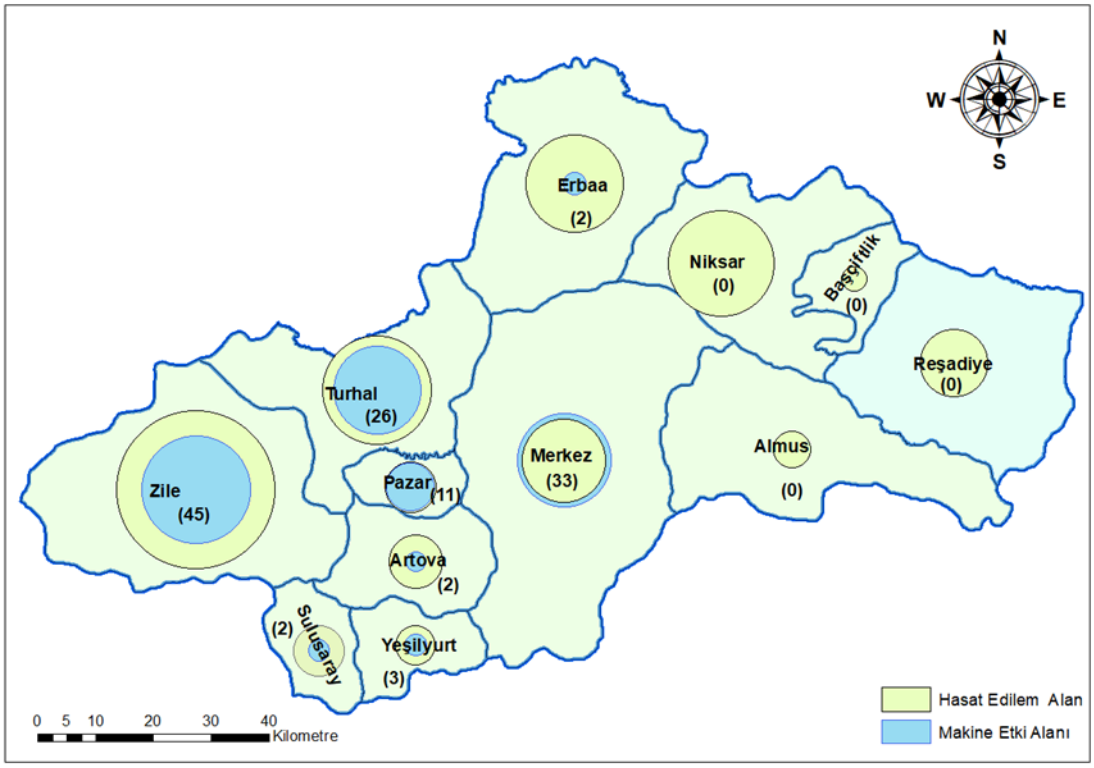

Figure 6. Map of machine numbers, harvested areas, and machine impact areas in the districts of Tokat
Şekil 6. Tokat ilçelerinin makine sayıları dağılım, hasat edilen alan ve makine etki alan haritası

Tractors

The maps of tractor-operated areas and machine impact areas for the districts of Tokat are shown in Figure 7. The total tractor-operated area in Tokat is 2.893.670 da and the operated area radius is 30.349 m. The total tractor impact area is 99.875.199 da and the impact area radius is 178.301 m. It was determined that the machinery (tractor) impact area is 35 times larger than the tractor-operated area in Tokat. Among the districts of Tokat, the highest value was obtained in the Merkez district 72 times, and the lowest value was obtained in the Sulusaray district 19 times.

There are 16.982 tractors in Tokat. While the required number of tractors is 500, it has been determined that there is an excess of 16.482 tractors. There is a considerable difference between these numbers, which is also significant for the national economy. A method must be devised by the government to find a solution. In the study conducted in Konya province, results with a similar trend were obtained (Yıldırım, 2019). While the lowest number of tractors is in Başçiftlik, the highest number of tractors is in the Merkez district. There are many times more tractors in each district than it should be. The reason for this can be said to be that tractor ownership is seen as social status, used in construction and transport works and unconscious planning.

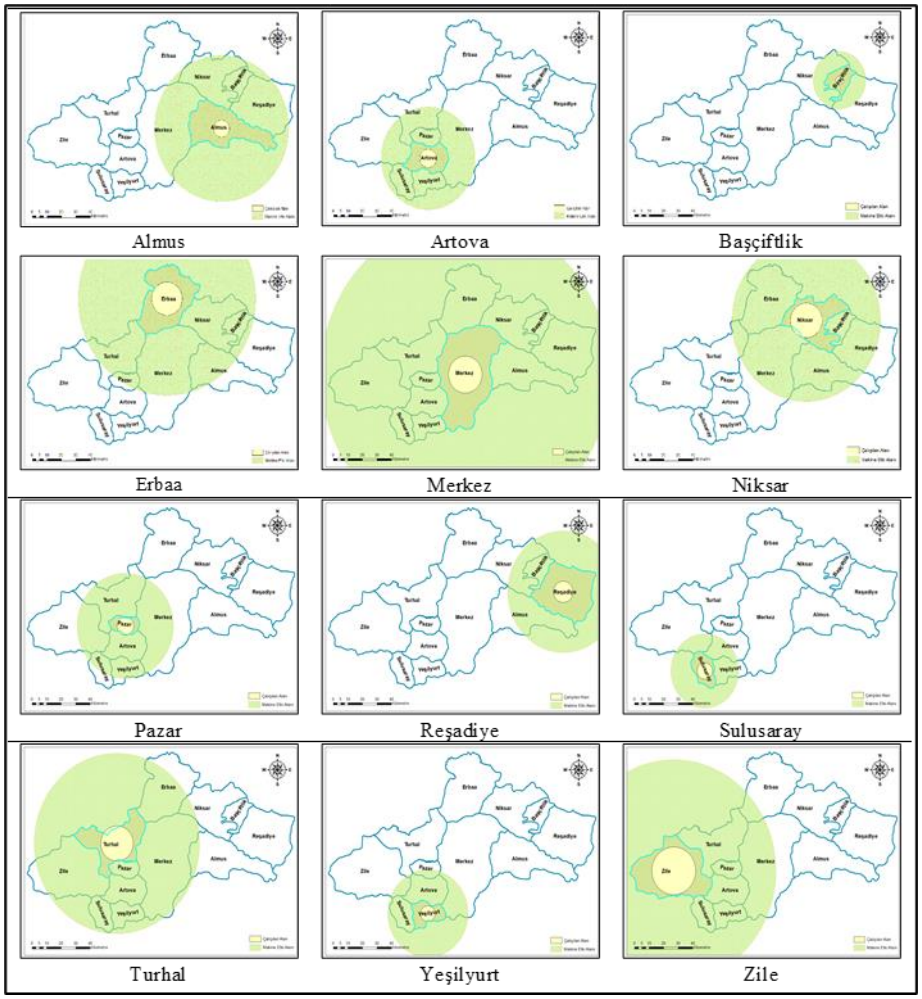

Figure 7. Maps of tractor-operated areas and machine impact areas in the districts of Tokat
Şekil 7. Tokat ilçelerinde traktörle çalışılan alan ve makine etki alan haritaları

Machine Utilization Efficiency

Up to this point, the machine utilization efficiency has been evaluated in the crops commonly cultivated in Tokat province. The machine utilization efficiency was also evaluated in areas only in wheat agriculture in Tokat province, and similar results were obtained.

When the 7 machinery groups determined for the plants commonly cultivated in Tokat are evaluated, there are 27.240 machines in the tillage tools/machinery group. The most surplus machines (21.964) are in this group. However, 5.276 machines are sufficient for the region. It is determined that the machine impact area is 70 times larger than the cultivated area in Tokat. In our country, traditional tillage still maintains its attractiveness and interest continues. For the machines in this group, methods such as renting and common use are generally not preferred. Farmers prefer to purchase machines that they can access more easily (such as small machines, and subsidized machines). In this context, the moldboard plow is the most preferred machine with an excess of 11.607 units. Stone collecting machines are generally used by the Tokat Directorate of Agriculture and Forestry through renting and also through a contracting system. Although the most needed machine is the stone collecting machine, it may not be correct to talk about its deficiency since it is supplied from nearby provinces through a contracting system. In particular, the lack of the subsoiler was determined in all districts (except Pazar and Zile districts). It is thought that the lack of a subsoiler is due to the lack of sufficient knowledge about this tool/machine. The misconception that the chisel plow performs the same task as the subsoiler also contributes to this conclusion. According to the districts, plant pattern and enterprise size also affect the need for machinery in this group. For example,

the fact that the excess of disc harrow is mostly in the Zile district may be due to the widespread sunflower agriculture.

In the sowing and planting machinery group, there are 1.505 machines. While a total of 872 machines are sufficient, an additional 633 machines are being used. It is determined that the machine impact area is approximately 2 times more than the planted area in the whole province. In Tokat province, where wheat is widely cultivated, combined seed drill is used the most and there are 489 extra machines. In the districts where this machine is lacking, broadcast sowing is preferred. Potato planting machines are in excess in the whole province. This is due to Niksar district where potato cultivation is intensive. Since tobacco is cultivated in Erbaa and Niksar, seedling planting machines are used only in these districts.

There is an excess in the total number of machines in the maintenance and fertilization machinery group. While the number of machines used is 3.284, it is determined that 1.016 machines are sufficient. It was determined that the machine impact area is 41 times more than the fertilized area in the whole province. The excess in this group is due to the chemical centrifugal fertilizer spreader, which is 2.062 more than normal. The reason for the excess of this machine is that it is used in wheat cultivation. The most needed machine is the manure spreading machine. The lack of this machine is because farm manure is widely distributed by manpower or soil leveling shovels in small enterprises throughout Tokat.

In the plant protection machinery group, of the 2.542 machines used, 2.329 are surplus. It was calculated that the machine impact area is 14 times more than the sprayed area in the whole province. Excess was found both in field crop sprayers and orchard sprayers. Especially motorized orchard sprayers are concentrated in the regions where garden agriculture is carried out in Tokat. It can be said that the reason for the idle machinery is that the enterprises prefer to purchase individually in order not to miss the limited agricultural protection periods.

There are 2.486 machines in the harvesting machinery group. While 2.218 machines are sufficient in total, an additional 268 machines are being used. Although the surplus seems to be relatively balanced, it is noteworthy that the need for balers and the surplus of other machines balance each other. In terms of the number of machines, there are deficiencies and excesses in this group among the districts. The number of balers needed in the whole province is 1.414 and this need is met through renting. The rental method is also used in the sugar beet harvester. The need for potato harvesters is met by using plows or cultivators for potato harvesting. It is determined that the machine impact area is 0.8 times smaller than the harvested area in Tokat.

It was calculated that the machine (combine harvester) impact area was 0.39 times smaller than the harvested area in Tokat. While there are 124 combine harvesters in the whole province, it was determined that there is a need for 209 more combine harvesters. The need for combine harvester in the season is met by the contracting system with combine harvesters from other provinces. Combine harvester contracting system is widely used in harvesting practices in our country and our region. The harvesting across the country starts on 15 May with wheat harvesting and ends in 2 to 2.5 months from the coastal region to the inland regions. Afterward, it continues with sunflower, maize, and rice harvesting. It may not be correct to talk about deficiency or excess due to the contracting system.

It is calculated that the machinery (tractor) impact area is 35 times larger than the tractor-operated area across Tokat. Although 500 tractors are sufficient in the whole province, it was determined that 16.482 tractors are surplus in the tractor-operated area. The reason for this can be said to be that tractor ownership is seen as a social status and it is used in construction and transport works as well as agricultural works. It is also utilized for investment purposes (Kasap et al., 1991).

In the evaluation of the machine utilization efficiency in only wheat agriculture and common crops cultivated, more deficiencies were detected in the machines (except balers) used in wheat agriculture for all machines where deficiencies were detected. This is due to the limited number of workable days. In terms of the number of machines, it was determined that the excess was less in the machines with more than the necessary number (except for the combined seed drill). For this reason, rather than making province or

district-wide planning, planning according to the plant pattern and enterprise-based planning will give more accurate results. Because the average data to be taken from large areas in mechanization planning may cause mistakes. Therefore, it would be more realistic to make planning from enterprise size to country-wide (Evcim, 1990).

CONCLUSION

Agricultural tools and machines used in only wheat agriculture and the common crops cultivated in 12 districts of Tokat province were classified into 7 groups. For the machines in each group, the machine impact areas were calculated based on the district, and the situation was determined for the machines in the machine groups by comparing them with the cultivated area. The number of machines in the group and the impact areas and cultivated areas converted into circular areas were converted into maps with the help of the ArcGIS 10.8 program.

In Tokat province where field, vegetable, and fruit agriculture are intensively carried out, the unbalanced distribution of machinery, i.e. the fact that the number of machinery is more or less than it should be, can be seen as a result of unplanned behavior. In this sense, it can be said that production planning is important and planning should be made according to the plant pattern.

The idle machines identified as a result of the study conducted for Tokat province cause high production inputs for the enterprises. For this reason, it can be suggested to use common machinery or to generalize machinery contracting system, to renew the machines that have completed their economic life, and to carry out state-supported projects for the machines whose deficiency is determined. Industrialists can also be guided and orientated according to the needs of the region.

CONFLICT OF INTEREST

There is no conflict of interest between the authors.

AUTHOR CONTRIBUTIONS

The authors' contributions to the article are equal.

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