

Spatial variation of agricultural land in Turkey using CORINE data

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ABSTRACT

Key words:
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Detection of the exchange and distribution of agricultural lands allows many projects and plans to be made and interpreted correctly, such as food safety, planning, and environmental risk analysis. From this point of study in the spatial changes and distribution of agricultural land in time across Turkey were examined. CORINE Land Cover (CLC) data was used to identify agricultural land and examine changes over time. As a result of the study, it was observed that agricultural lands increased slightly from 1990 to 2018, but this increase has not always been in the form of preserving existing agricultural lands and adding existing agricultural lands. While some areas have lost their agricultural land characteristics, some areas have become agricultural land. New agricultural areas are usually realized by the transformation of forests and semi-natural areas while the agricultural areas that disappear are provided from heterogeneous agricultural areas. The Central Anatolia region stands out in the distribution of agricultural areas by region. The region with the highest concentration of agricultural land in terms of both proportion and area is the Central Anatolia region. Also, the Central Anatolia region is the region with the most intensive Non-irrigated agriculture. The area where irrigated agriculture is proportionally most made is the southeast Anatolia region. According to province-based, the provinces with more than 40% of the provincial surface area are Kırıkkale, Kırşehir, Nevşehir, Aksaray in the Central Anatolia region, Gaziantep and Şanlıurfa in the Southeastern Anatolia region, Edirne and Tekirdağ in the Marmara region. The provinces of Artvin, Tunceli, Bingöl, and Hakkari are the provinces where the percentage of agricultural land is below 10%.

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1. Introduction

Determining the characteristics of the agricultural land cover of an area and examining its change over time enables many plans and projects such as strategic planning, productivity analysis, environmental impacts and risk analysis, which are essential in the agricultural sector, to be carried out accurately. From this point of view, this study purpose to analyze the main land use and spatial changes of land cover categories across Turkey over time using the CORINE Land Cover (CLC) database. Thus, it will be possible to provide quantitative answers to questions such as how much area rural areas cover in Turkey, how much and where they have spread more over time, and which land types have been negatively affected during rural changes.

Basically, two perspectives dominate in the study. The first one is the change of agricultural areas over time and the second is the determination of the current situation. The most recent CORINE data system (2018) has been used for the distribution of agricultural land by country-wide, geographical regions and provinces. For the aerial change of agricultural lands over the years, data sets for 1990 and 2018 were used.

Turkey is a region in the territory of the agricultural field in the determination of the current status and land of many studies are available in the monitoring (Dengiz et al. 2006; Tuğaç and Torunlar

2007; Sargin and Akengin 2009; Üçeçam Karagel and Karagel 2009; Özgün 2012; Karabacak and Özçağlar 2013; Bayar 2018; Bozkoyun et al. 2019; Tabakoğlu 2019; Alevkayalı and Tağıl 2020; Boz 2020; Yılmaz and Dengiz 2021; Okudan and Bayar 2022). Maps and aerial photographs obtained by remote sensing methods are the main sources of data if the maps and studies prepared on various dates were examined while examining the status and changes of rural land regions (Çolak and Memişoğlu 2017; Turan et al. 2021; Özüpekçe 2021). CORINE data prepared using satellite images were preferred in this study. The fact that there is no study on the temporal change of agricultural areas in Turkey in the relevant literature was the main motivating factor for the study. The CORINE data set from satellite photographs has been used in many studies in the detection and exchange of agricultural lands (Vard et al. 2005; Feranec et al. 2007; Paracchini et al. 2008; Vaz et al. 2011; Alp et al. 2015; Gardi et al. 2015; Paşca and Näsui 2016; Assenov and Grigorov 2018; Vizzari et al. 2018; Bozhkov et al. 2022; Custovic et al. 2023; Özcanlı 2022). Along with agricultural purposes, CORINE data allows monitoring of endangered territories (Nikolova et al. 2021; Todorov and Kirilov 2022) and could provide valuable information for mapping of ecosystems at a national level (Hristova and Stoycheva 2021).

Regarding data quality and its usability in Turkey, Özüer and Ataol (2018) emphasize that CORINE data is useful and can be used in land use studies. In the meantime, the biggest criticism for the data set is the inability to show detail. The minimum mapping unit in the resulting land cover maps is 25 ha (Ministry of Agriculture and Forestry of Turkey 2021). In order to map a land with other words, it must cover at least 25 hectares of land homogeneously (CLSM 2023). Therefore, data for micro studies are quite insufficient. However, considering that this study was conducted across Turkey, it is thought that this fault can be ignored.

2. Materials and methods

The CORINE (Coordination of Information on The Environment) data is derived from the work carried out within The Copernicus Land Monitoring Service (CLMS) project of the European Environment Agency (CLMS 2023). The project started in 1985 and its main aim is to provide spatial data on a European scale. The first land cover data produced under the project dates back to 1990. The data prepared with a 10-year interval in the first period started to be updated every 6 years since 2006. For this reason, land cover data for 1990, 2000, 2006, 2012 and 2018 are available. Each data occurs from 44 separate land covers within 5 basic groups in the year it has (Table 1).

The numbers used for classification in Table 1 will be used as the code for the maps and graphs in the study. For example, in the first level land cover patterns, agricultural areas are denoted by 2, arable lands, which constitute a subset of agricultural areas, are denoted by 2.1, and Non-irrigated agricultural areas, one of the third level land use patterns, are denoted by 2.1.1.

CORINE data for the years 1990, 2000, 2006, 2012 and 2018 were downloaded in vector format from CLMS (2023) and introduced to the ArcGIS 10.1.4 Geographic Information System (GIS) package program. Since each of the data studied is Europe-wide, countries that other than Turkey were excluded in the first place. The coordinate system of the spatial data provided by the European Union Environment Agency is ETRS 1989 LAEA and the datum is D ETRS 1989. The vector data was converted to the TUREF LAEA Europe coordinate system and the Turkish National Reference Frame datum D in order to get more realistic results in the area calculations. Therefore, all areal data obtained in the study were calculated according to the TUREF LAEA Europe coordinate system.

In the study, Hot Spot analysis was used to show the areas where land cover has lost its agricultural land feature over time or where land cover that was not agricultural land in 1990 but classified as agricultural land in 2018 is concentrated (Fig. 1).

The Getis-Ord local statistic (Getis and Ord 1992) is given as:

$$G_i^* = \frac{\sum_{j=1}^n w_{ij} - \bar{x} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{ij} - (\sum_{j=1}^n w_{ij})^2}{n-1}}} \quad (1)$$

Where x_i is the attribute value for feature i , w_{ij} is the spatial weight between feature i and j , n is equal to the total number of feature and (Ord and Getis 1995; El-Basyouny and Sayed 2009):

$$\bar{x} = \frac{\sum_{j=1}^n x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^n x_j^2}{n} - \bar{x}^2} \quad (3)$$

Two separate hot spot analyses were conducted for the areas that lost their agricultural characteristics and gained non-agricultural characteristics. One of these is the hot spot analysis, which shows lost agricultural land. The areas with a confidence interval of 95% and above for artificial fields, forest and semi-natural sites, wetlands and water structures are mapped (Fig. 9).

3. Results

As a result of the CORINE data prepared for the years 1990, 2000, 2006, 2012 and 2018, agricultural areas are the first-degree CORINE class that occupies the most area after forests and semi-natural areas in Turkey (Fig. 1). Looking at the distribution of agricultural land according to the data years, agricultural land cover, which was 334 737 km² in 1990, decreased by 2 467 km² in 2000 compared to the previous year to 332 270 km². 2000 is the year with the lowest agricultural land cover in Turkey according to CORINE data.

In 2006, agricultural areas increased by 2% from 332 270 km² in 2000 to 339 912 km². In 2012, CORINE data shows that agricultural land occupied the largest area. This year, Turkey's general agricultural area amount is 341 306 km². In 2018, the agricultural area size decreased to 340 722 km².

When agricultural areas are considered as a whole, it is seen that they have not changed much in proportion over the years. For instance, between 1990 and 2000, the area covered by artificial areas in Turkey increased by 27%. It increased by 7% between 2000-2006, 8% between 2006-2012 and 11% between 2012-2018. An increase of 63% was observed between

1990 and 2018. Between 1990–2018, wetlands changed by 62%, water structures by 17%, forest and semi-natural areas by 4%, while agricultural areas changed by 2% at most in the last 28 years.

In the CORINE classification, agricultural areas have four sub-categories: arable areas (2.1), permanent agricultural areas (2.2), pastures (2.3) and heterogeneous agricultural areas (2.4) (Table 1).

Arable fields within agricultural fields cover the widest area for each period. It accounts for more than 50% of total agricultural land for each data year (Fig. 2).

Table 1. CORINE Land Cover classes.

Level 1	Level 2	Level 3	
1. Artificial surfaces	1.1 Urban fabric	1.1.1 Continuous urban fabric	
		1.1.2 Discontinuous urban fabric	
	1.2 Industrial, commercial and transport units	1.2.1 Industrial or commercial units	
		1.2.2 Road and rail networks and associated land	
		1.2.3 Port areas	
		1.2.4 Airports	
	1.3 Mine, dump and construction sites	1.3.1 Mineral extraction sites	
		1.3.2 Dump sites	
		1.3.3 Construction sites	
	1.4 Artificial, non- agricultural vegetated areas	1.4.1 Green urban areas	
		1.4.2 Sport and leisure facilities	
	2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land
2.1.2 Permanently irrigated land			
2.1.3 Rice fields			
2.2 Permanent crops		2.2.1 Vineyards	
		2.2.2 Fruit trees and berry plantations	
		2.2.3 Olive groves	
2.3 Pastures		2.3.1 Pastures	
2.4 Heterogeneous agricultural areas		2.4.1 Annual crops associated with permanent crops	
		2.4.2 Complex cultivation patterns	
		2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation	
		2.4.4 Agro-forestry areas	
3. Forest and semi-natural areas		3.1 Forests	3.1.1 Broad-leaved forest
			3.1.2 Coniferous forest
			3.1.3 Mixed forest
		3.2 Scrub and/or herbaceous vegetation associations	3.2.1 Natural grasslands
			3.2.2 Moors and heathland
	3.2.3 Sclerophyllous vegetation		
	3.2.4 Transitional woodland-shrub		
	3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes, sands	
		3.3.2 Bare rocks	
		3.3.3 Sparsely vegetated areas	
		3.3.4 Burnt areas	
		3.3.5 Glaciers and perpetual snow	
4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes	
		4.1.2 Peat bogs	
	4.2 Maritime wetlands	4.2.1 Salt marshes	
		4.2.2 Salines	
		4.2.3 Intertidal flats	
	5. Water bodies	5.1 Inland waters	5.1.1 Water courses
5.1.2 Water bodies			
5.2 Marine waters		5.2.1 Coastal lagoons	
		5.2.2 Estuaries	
		5.2.3 Sea and ocean	

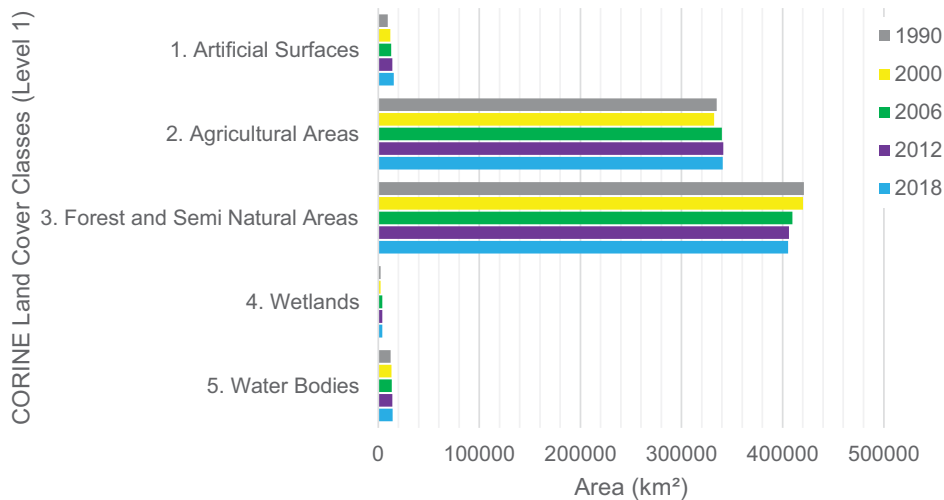


Figure 1. Distribution of land in Turkey according to CORINE land cover classes.

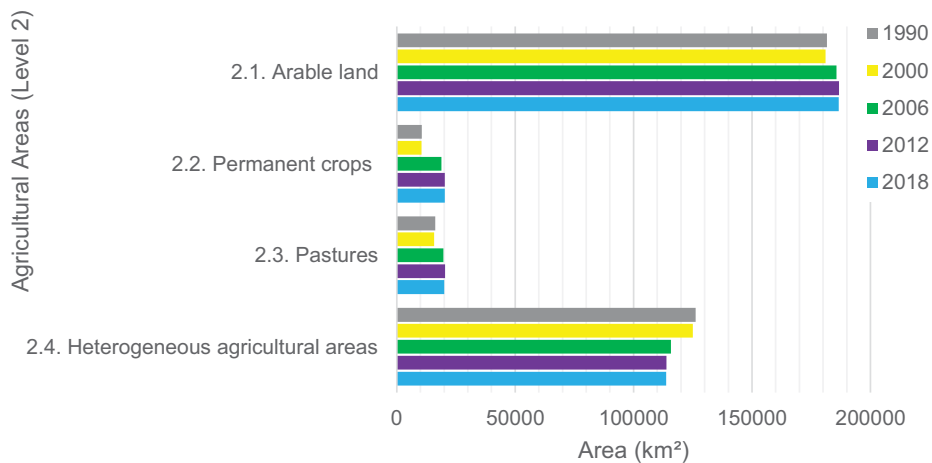


Figure 2. Distribution of agricultural areas by year in CORINE land cover classes.

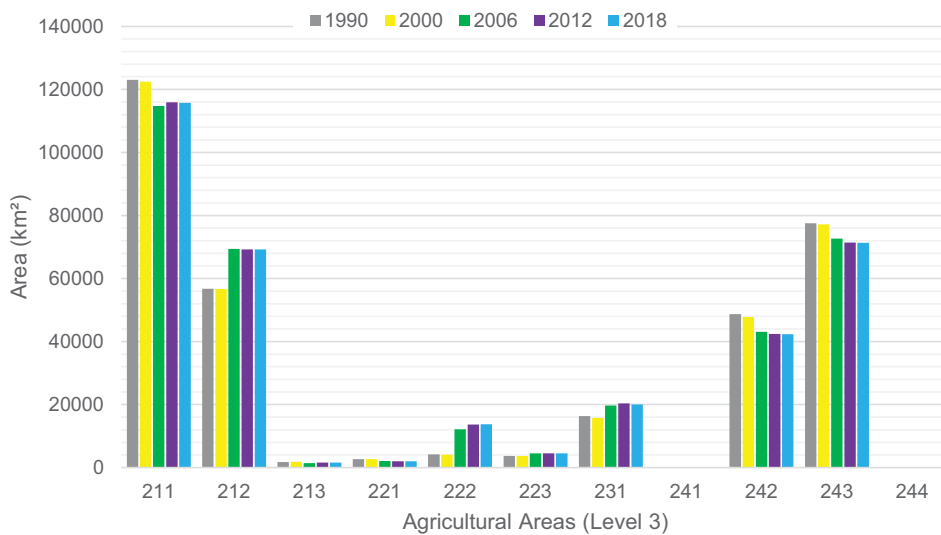


Figure 3. Distribution of agricultural areas by year in CORINE land cover classes.

It was mentioned in the previous lines that agricultural areas have not changed much in CORINE first-level land use patterns. There are significant percentage changes in the second-level land use patterns under the heading of agricultural areas. For example, the area of permanent agricultural land (2.2) increased by 90% from 1990 to 2018. Between the same years, pastures (2.3) and arable land (2.1) increased by 23% and 3%, respectively, while heterogeneous agricultural areas (2.3) lost 10% of its area (Fig. 2).

Looking at the third-degree land use patterns of agricultural areas, it is seen that Non-irrigated arable land (2.1.1) under the title of arable land is the land cover that covers the most area for each period. For each period, Non-irrigated arable land accounts for more than one-third of the total agricultural area (Fig. 3). Non-irrigated arable lands are followed by agricultural areas (2.4.3), Permanently irrigated lands (2.1.2), and heterogeneous agricultural areas (2.4.2).

Non-irrigated arable land (2.1.1), heterogeneous agricultural land (2.4.2), and agricultural land with natural vegetation (2.4.3) have decreased since 2000. Irrigated agricultural areas (2.4.3), fruit trees (2.2.2), and pasture areas (2.3.1) increased after 2000 (Fig. 3).

For Turkey as a whole, the change in third-level land cover patterns has been proportionally higher. For example, in the period 1990–2018, fruit trees coded 2.2.2 increased by 23%, pasture areas coded 2.3.1 increased by 23%, olive groves coded 2.2.3 increased by 23% and irrigated agricultural areas coded 2.1.2 increased by 22%. On the other hand, vineyards (2.2.1) decreased by 23%, heterogeneous agricultural land (2.4.2) by 13%, rice fields (2.1.3) by 12%, agricultural areas with natural vegetation (2.4.3) by 8%, and non-irrigated arable areas (2.1.1) by 6% between 1990 and 2018.

3.1. New agricultural areas

In 1990, the area of areas considered as agricultural land was 334 737 km². In 2018, it reached 340 722 km². In other words, approximately 6000 km² of agricultural area has increased across Turkey in 28 years, but this increase has not always been in the form of preserving existing agricultural areas and adding to existing agricultural areas. Some areas have lost their agricultural land characteristics while some areas have become agricultural land. Turkey from 1990 to 2018

in the time of 36 345 km² new agricultural land has been added. On the other hand, 30 361 km² of agricultural land has disappeared in this period.

A significant portion of the areas that were not agricultural areas in 1990 but became agricultural areas in 2018 are forested and semi-natural areas within the first-degree CORINE classification areas. Looking at the second level changes, they are bushes and/or herbaceous plant communities at the beginning of the fields that turned into agricultural land in 2018. A significant part of the bushes and/or herbaceous plant communities have been converted into meadows and heterogeneous agricultural land. The most noticeable change in the third-level land cover classification is the area of natural grassland (3.2.1). In 1990, the areas that were grassland were transformed into pasture areas (2.3.1) (Fig. 4).

In 1990, the areas where the areas classified as agricultural land were most concentrated were Şanlıurfa, Ardahan and Mersin (Fig. 5). These areas are also areas with relatively more natural vegetation and semi-natural areas.

3.2. Disappearing Agricultural Areas

The agricultural area in 1990 and the total area covered by the fields that lost the agricultural area feature in 2018 was 30 018 km², and the majority of the changing agricultural areas were experienced in heterogeneous agricultural land (2.4) (Fig. 6). While heterogeneous agricultural land (2.4) covered 77 558 km² in 1990, 13 551 km² of these areas lost their agricultural characteristics in 2018. After heterogeneous agricultural land, the highest agricultural area was realized in cropland. The arable agricultural area (2.1) 5 987 km², which covered an area of 181 633 km² in 1990, had a non-agricultural use in 2018. On the other hand, a significant number of areas that lost their agricultural characteristics (22 058 km²) have become semi-natural sites (Fig. 6). Land principally occupied by agriculture, which is under the heading of heterogeneous agricultural land (2.4) when the fields that lost their agricultural land feature in the period from 1990 to 2018 were examined according to the third-degree land classification status, with significant areas of natural vegetation (2.4.3). 2.4.3 is followed by Complex Cultivation Patterns (2.4.2).

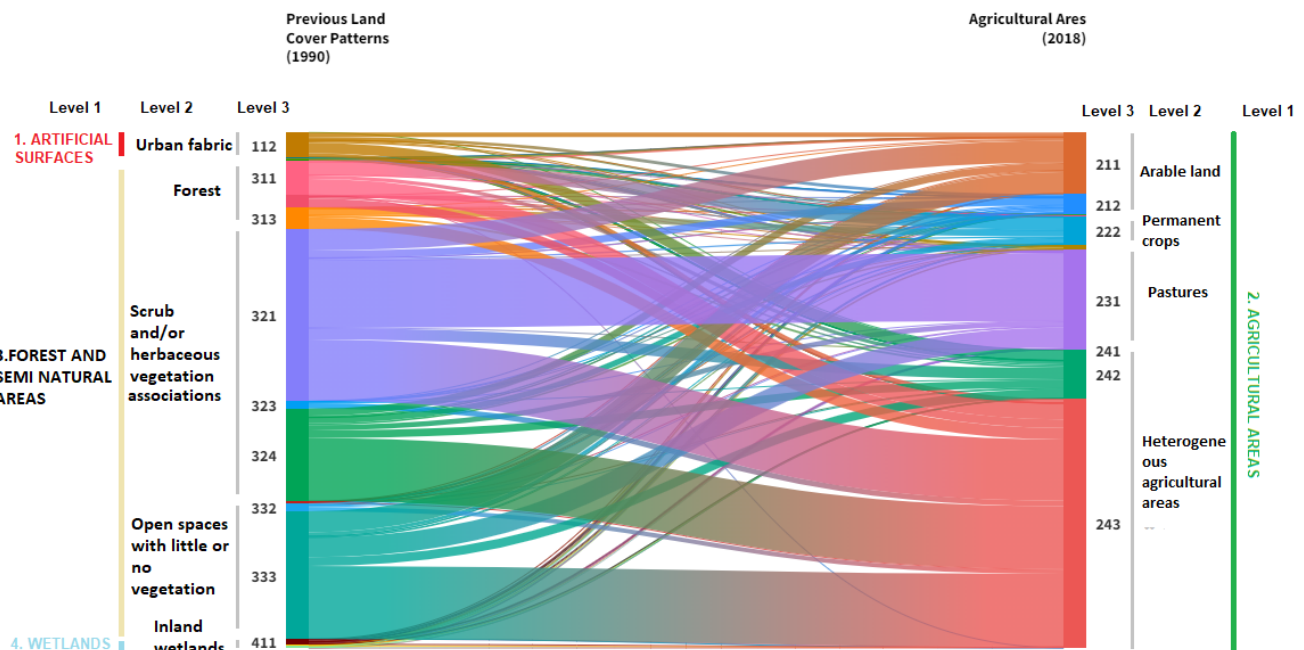


Figure 4. Areas that were not agricultural land in 1990 but classified as agricultural land in 2018.

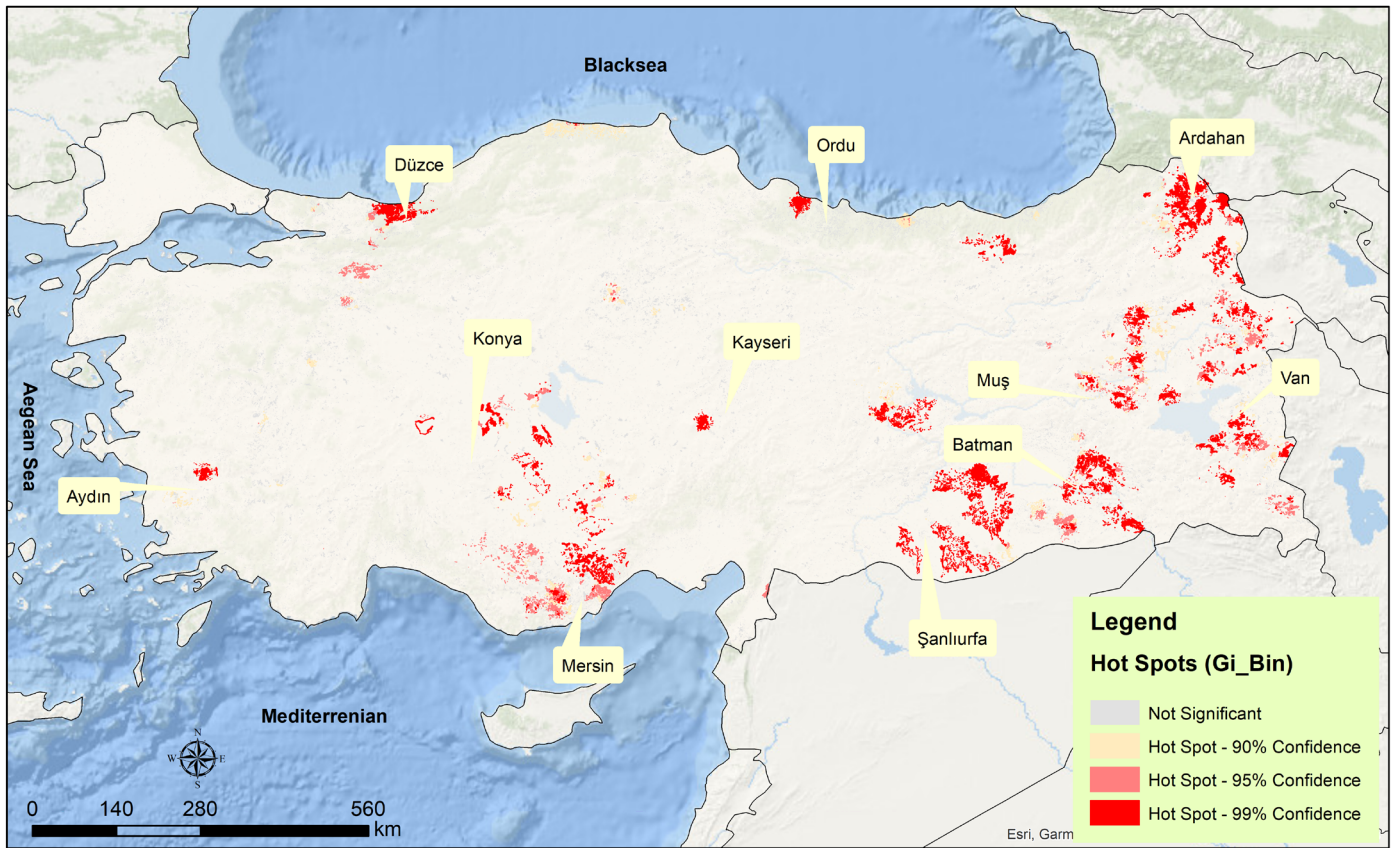


Figure 5. Hotspot analysis of areas that were not agricultural land in 1990 but classified as agricultural land in 2018.

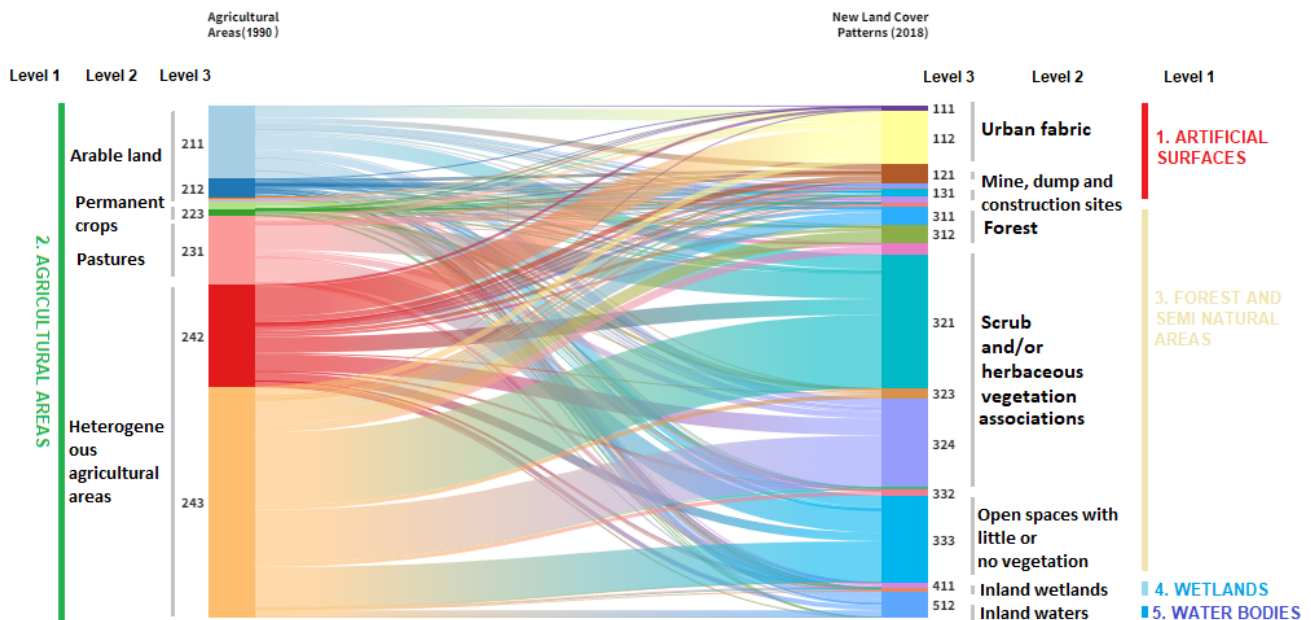


Figure 6. Areas that were agricultural areas in 1990 but lost their agricultural characteristics in 2018.

In 1990, the areas that were agricultural land but lost this characteristic in 2018 and were used for other purposes are concentrated in the eastern parts of the country, especially in provinces such as Sanliurfa and Bingöl (Fig. 7).

When the hot spot analysis is made according to the use groups in 2018, it is seen that the places where agricultural land has lost its agricultural land characteristics and turned into artificial fields are

concentrated in places where Turkey's major provinces such as Istanbul, Ankara, Izmir, Bursa, Konya, Antalya and Adana are located (Fig. 8). Areas that were agricultural land in 1990 and became semi-natural areas in 2018 are generally concentrated on the east coast of the country. In 1990, a small part of the agricultural land was covered by water (Fig. 8). This is most obvious in the provinces of Adiyaman and Sanliurfa in the Southeastern Anatolia Region.

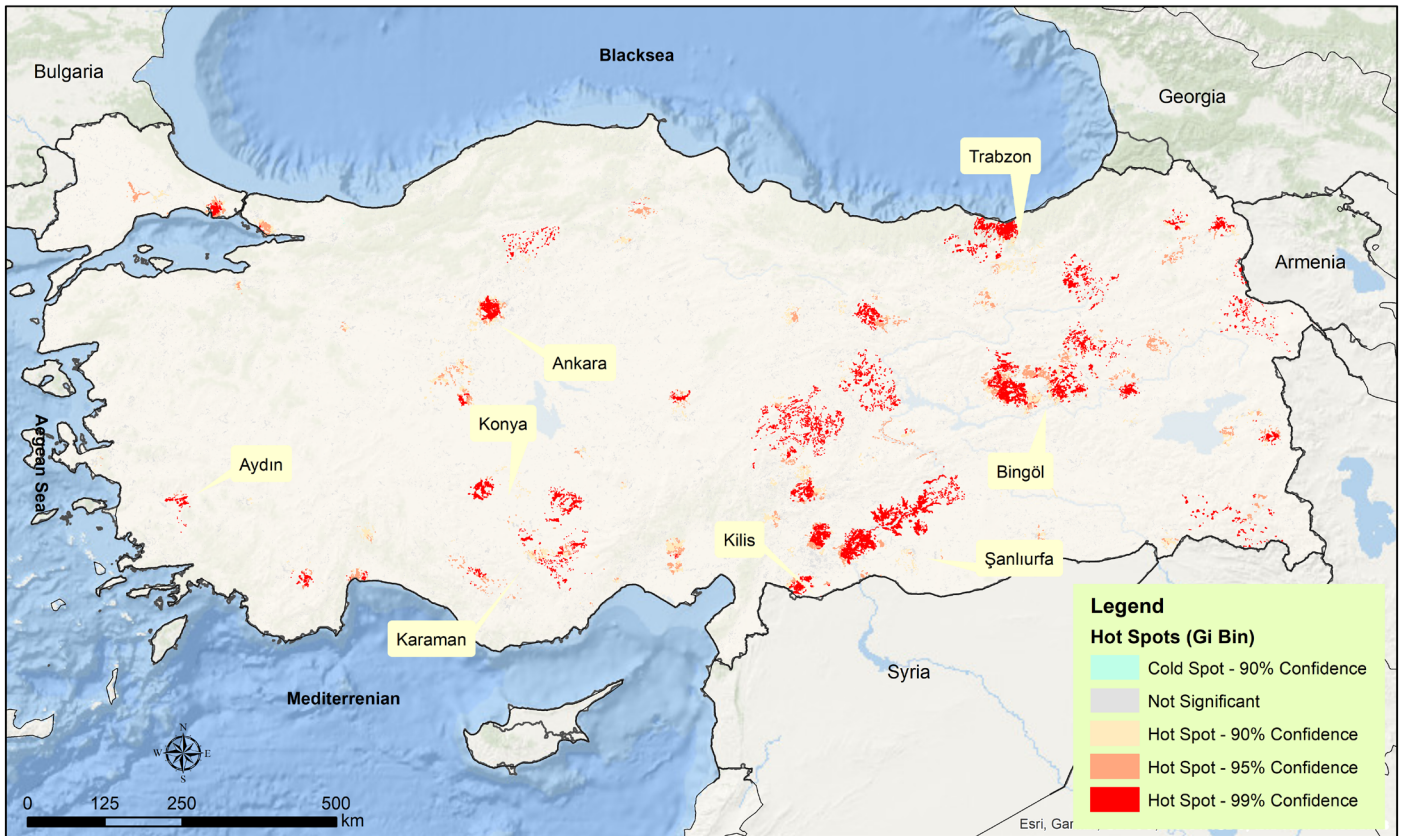


Figure 7. Areas that lost their agricultural characteristics and gained non-agricultural characteristics.

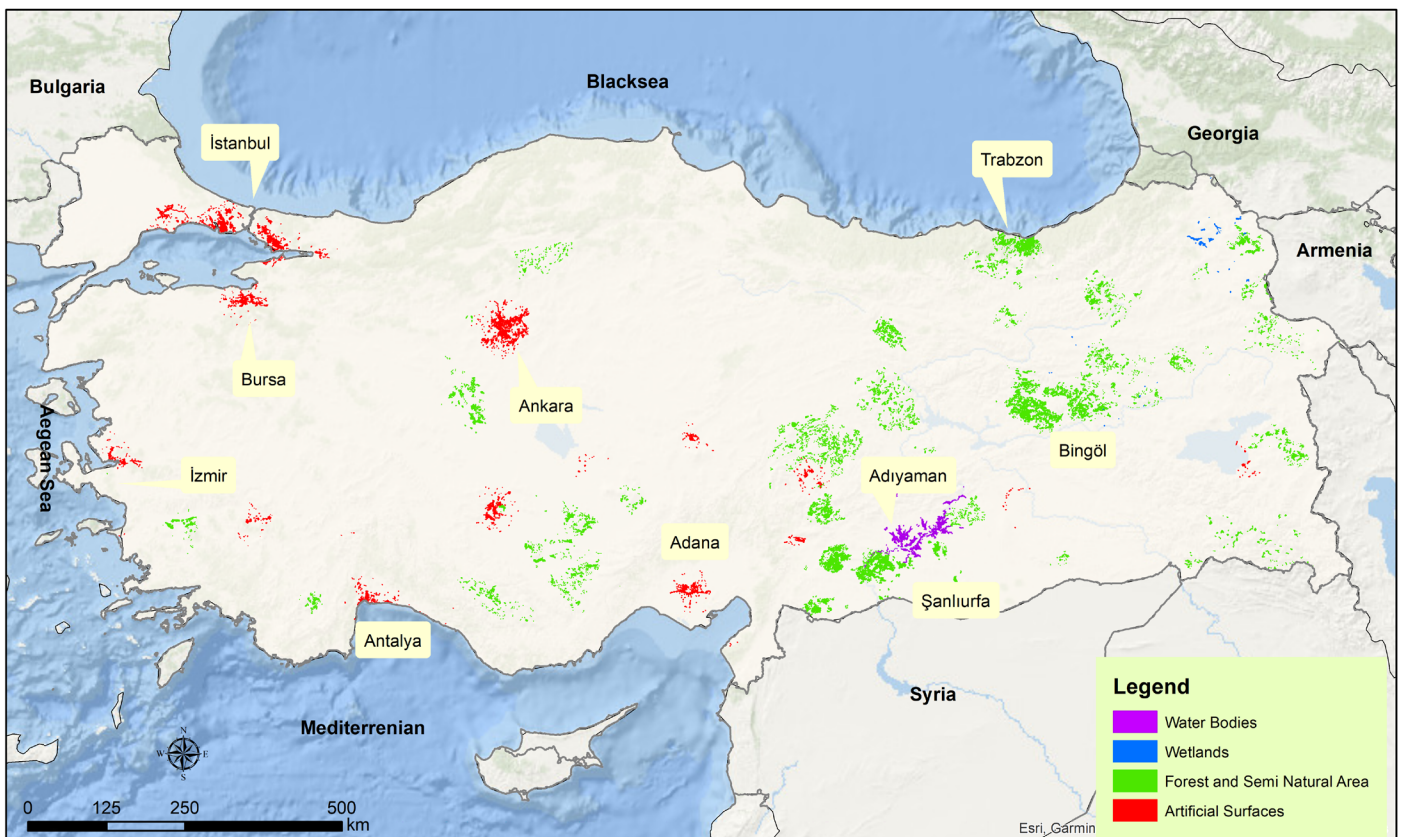


Figure 8. Hot-Spot representation of the areas that lost agricultural characteristics and gained non-agricultural characteristics according to use groups.

With the 1992 construction of the Atatürk Dam, 378 km² of agricultural land was submerged under the dam waters. On the other side, however, there has been an increase in irrigated agricultural areas with the dam.

3.3. Distribution of agricultural lands

Based on 2018 CORINE data, the distribution of agricultural areas across regions is dominated by the Central Anatolia region. Agricultural areas in the Central Anatolia Region are nearly 98 thousand km², which amounts to 29% of the total agricultural area in Turkey. Central Anatolia is followed by Eastern Anatolia with 16%, Black Sea with 13%, Southeastern Anatolia with 11%, Mediterranean with 11%, Aegean with 11% and Marmara with 9%. The Southeastern Anatolia region takes the lead in terms of the ratio of agricultural areas to the surface area of the region. Agricultural lands in Southeastern Anatolia represent 39% of the region's surface area. The Southeastern Anatolia Region is followed by the Central Anatolia Region with 38%, the Marmara Region with 34%, the Aegean Region with 31%, the Black Sea and Mediterranean Regions with 25%, and the Eastern Anatolia Region with 24%.

Arable land is the second-level land cover pattern, covering the most area in four of the seven geographical regions. Particularly the Central Anatolia Region has the highest area and proportion of arable agricultural land. In the Black Sea, Aegean and Mediterranean regions, heterogeneous agricultural land are more significant (Fig. 9).

When the agricultural land cover at the third level of the CORINE dataset is analyzed, Non- irrigated arable land is the domi-

nant land cover pattern for three regions (Central Anatolia, Eastern Anatolia and Marmara Region) (Fig. 10). In fact, the area under Non-irrigated arable land in Central Anatolia constitutes more than 50% of the total agricultural area in Central Anatolia. The land where Non-irrigated arable land is practiced in the Central Anatolia region is 52 thousand km² on average. This is approximately equivalent to the entire agricultural land in the South Eastern Anatolia region. In the Mediterranean, Black Sea and Aegean regions, Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3) is the land cover type that covers the most area. The region with the highest area of irrigated agricultural land in total land area is the South-eastern Anatolia region.

In the distribution of agricultural areas by provinces, Konya (24 429 km²), Ankara (14 285 km²), Şanlıurfa (13 640 km²) and Sivas (10 944 km²) come to the fore. The fact that the agricultural areas in these provinces are higher than the other provinces in Turkey is also influenced by the fact that the surface area of these provinces is above the average. Therefore, the percentage of agricultural land in the provinces according to the surface area of the provinces was calculated (Fig. 11).

The province with the highest proportion of agricultural land to province area is Kilis with 51% agricultural land. Kilis is followed by Nevşehir with 50%, Şanlıurfa with 45%, Tekirdağ with 44% and Edirne with 43%. On the other hand, Hakkari with 6%, Artvin with 7%, Bingöl with 9%, Tunceli with 9%, and Gümüşhane with 12% are the provinces with the least agricultural area compared to the provincial area.

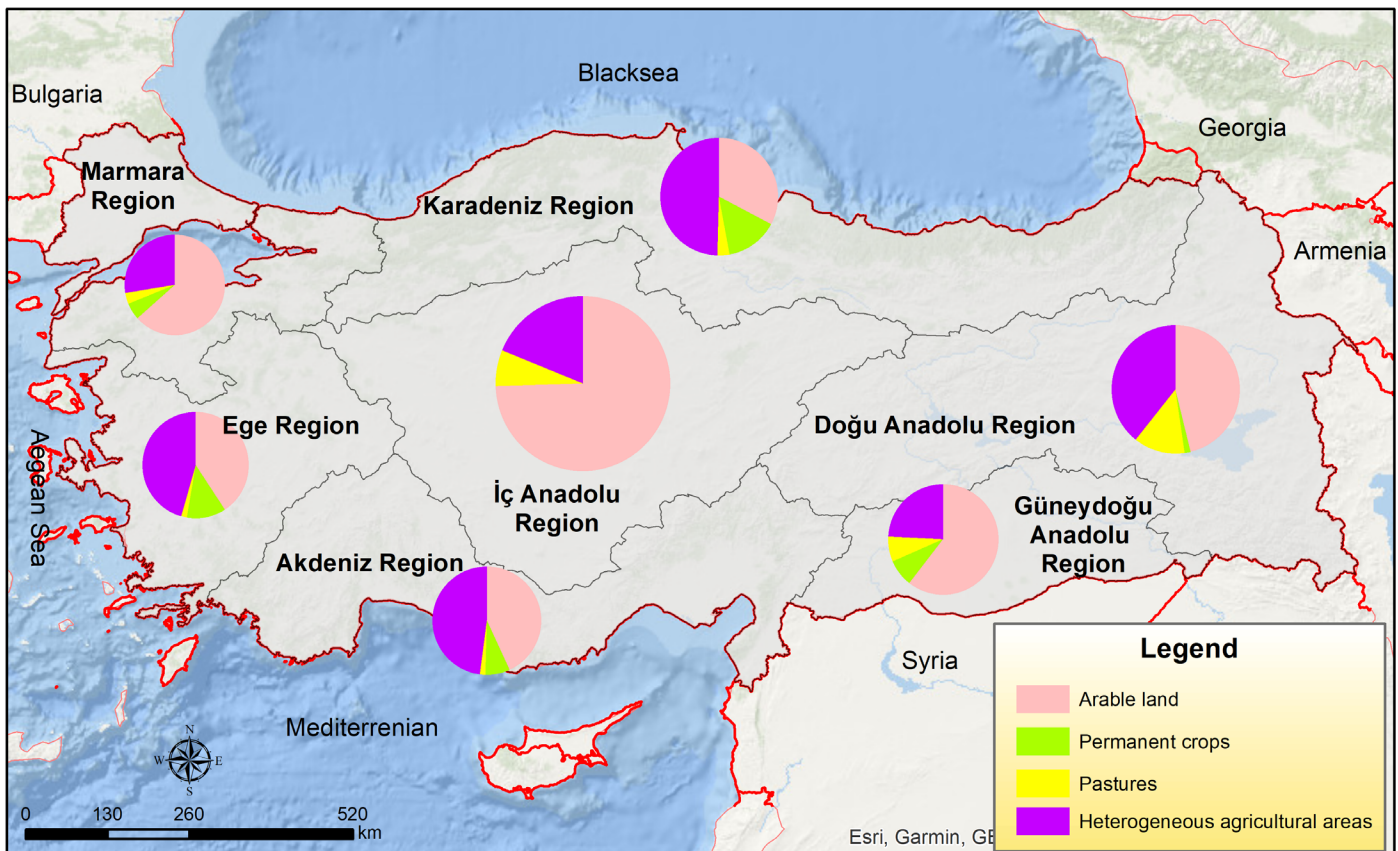


Figure 9. Second level CORINE agricultural land use by region.

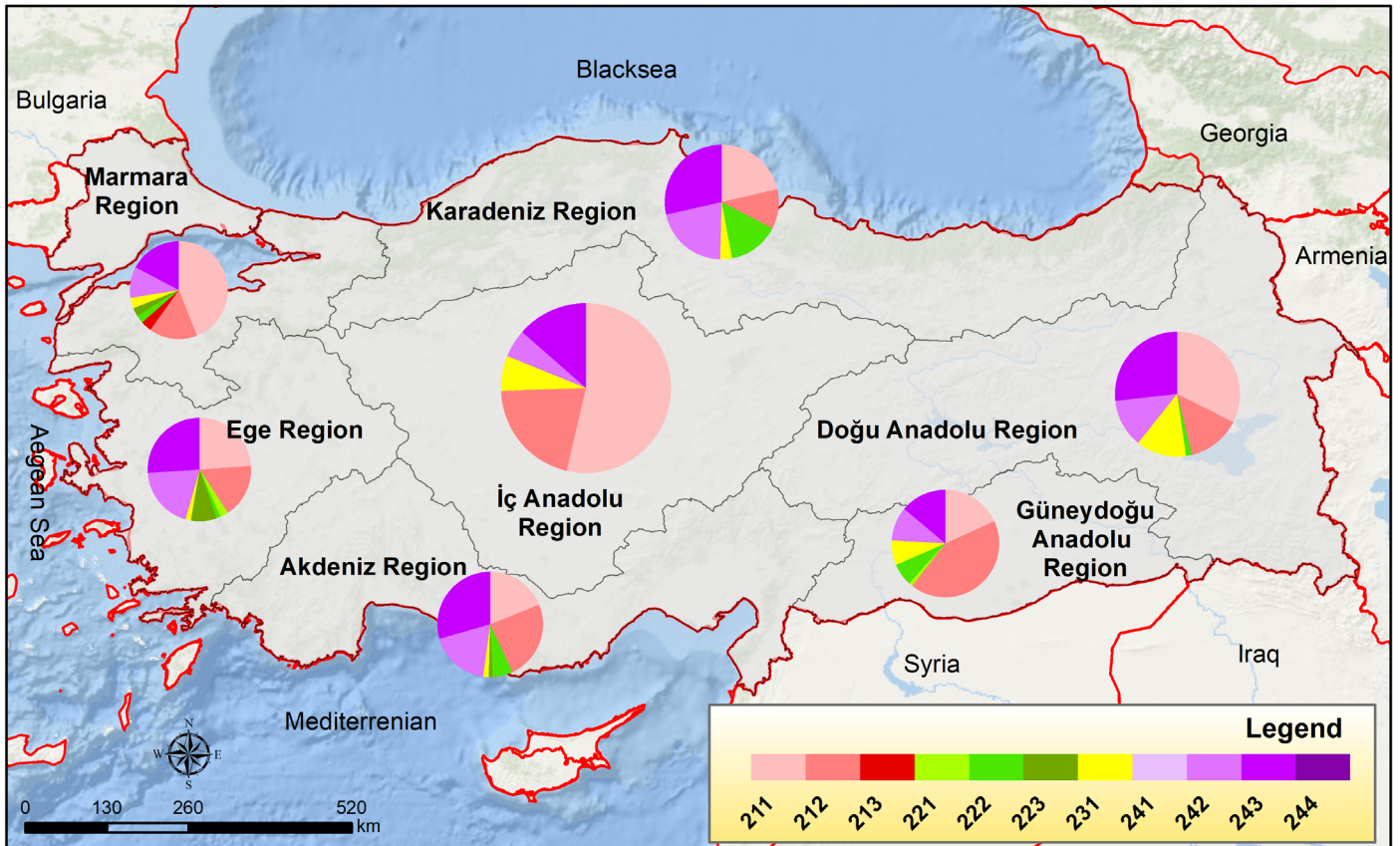


Figure 10. Second level CORINE agricultural land use by region.

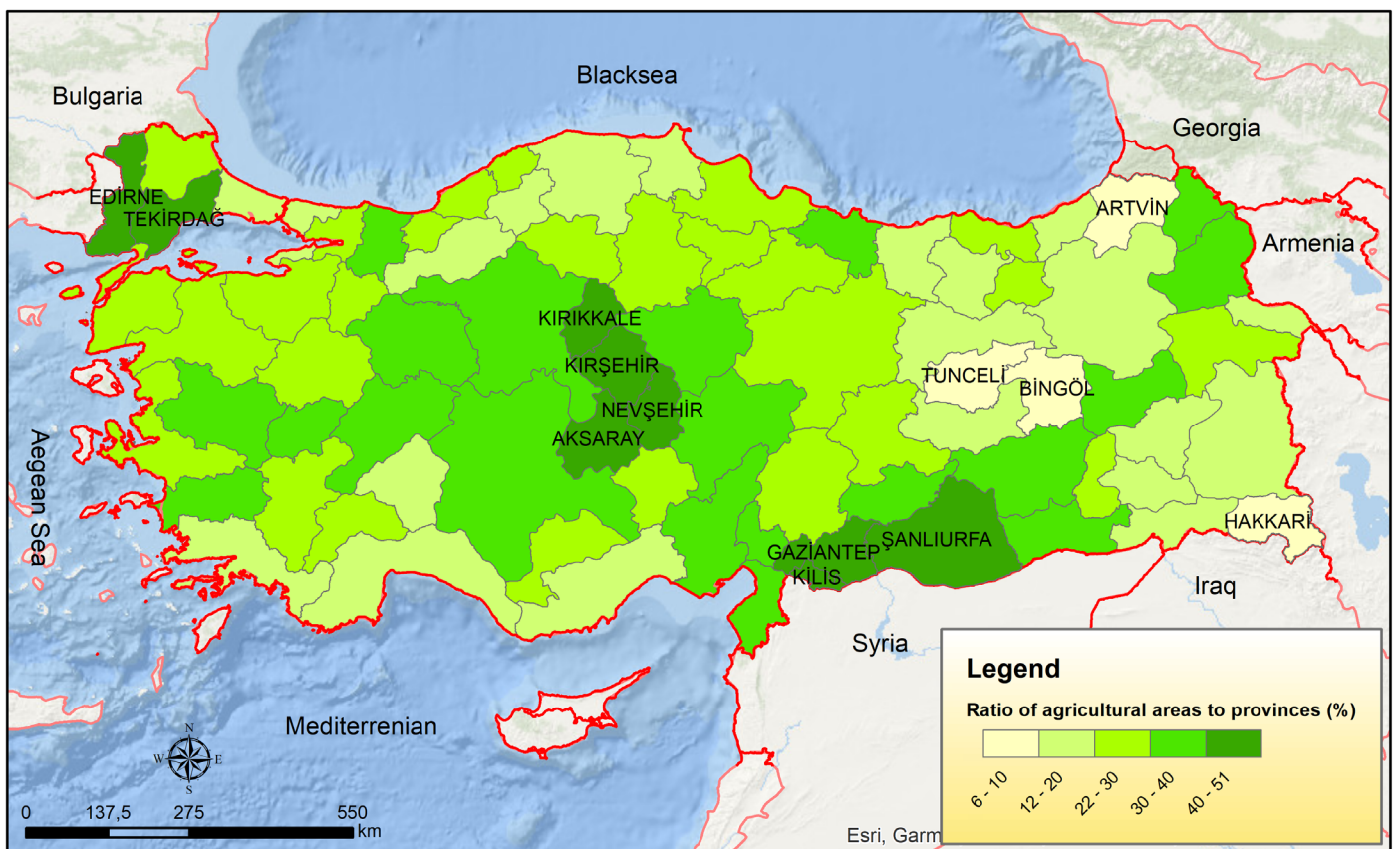


Figure 11. Percentage of agricultural areas to the area of the province.

4. Conclusion

In order to ensure sustainable and planned land use, it is of great importance to follow the rapid changes in land use. Meeting the needs of the increasing population, technological developments and getting maximum yield from minimum area increase the impact of humans on land and allow land use to change.

In this study, the general situation of the change in agricultural land cover across Turkey according to ten CORINE datasets was evaluated. Accordingly, agricultural land cover in Turkey increased by 2% from 1990 to 2018. Between 1990 and 2018, approximately 30 thousand km² of agricultural land disappeared, while nearly 36 thousand km² became agricultural land. Both the new agricultural areas and the disappeared agricultural areas are— according to the second level CORINE classification—heterogeneous agricultural areas. In 2018, the land that became agricultural land was mainly concentrated in provinces such as Ardahan, Batman, Sanliurfa and Mersin. In 1990, the areas that were agricultural areas although they lost this characteristic are concentrated in areas such as Bingöl, Adiyaman and Sanliurfa. According to latest CORINE dataset, the region with the highest agricultural area is Central Anatolia. In the Central Anatolia Region, arable land in obvious accounts for about three quarters of the total agricultural land. Especially non-irrigated arable lands have an important place in arable agricultural areas. At the provincial scale, the provinces with more than 40% of the provincial surface area are Kırıkkale, Kırşehir, Nevşehir, Aksaray in the Central Anatolia Region, Gaziantep and Sanliurfa in the Southeastern Anatolia Region, Edirne and Tekirdağ in the Marmara Region. Artvin, Tunceli, Bingöl and Hakkari are the provinces where the ratio of agricultural land is below 10%.

In a country with highly productive agricultural lands, increasing the share of agriculture in the economy is only possible by finding solutions to agricultural problems, developing agricultural policies and using agricultural areas properly.

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Conflict of interest

The authors have declared that no competing interests exist.

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