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Investigations of Spatial and Temporal Land Use/Land Cover Changes in Trabzon Province (1990-2018) Using CORINE Maps and Landscape Metrics

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Abstract: In this study; it is aimed to analyze the temporal and spatial changes in land use/land cover of Trabzon province with the population increase in the 28-year period between 1990-2018 by analyzing it with CORINE maps and landscape metrics. Within the scope of the study, temporal variation analysis was carried out using CORINE maps of the years 1990, 2000, 2006, 2012 and 2018. In Trabzon, according to the CORINE classification system, a total of 4 main groups have been identified at the first level, and at the third level, 19 land use/land cover classes have been identified for 1990, 20 for 2000, 24 for 2006, and 26 for 2012 and 2018. It was observed that the most differentiation occurred in the agricultural areas class in the 28-year period. In addition, the metrics of class area (CA), number of patches (NumP), mean patch size (MPS), edge density (ED), total edge (TE) and mean shape index (MSI) were calculated through ARCGIS's Patch Analyst plugin in the study. The changes that have occurred have been examined. Accordingly, there has been a decrease in the size of forest and seminatural areas and agricultural areas with the increase in the size of the artificial surfaces due to the increase in human activities and population over the past 28 years. In addition, due to the continuous increase in the number of patches in the agricultural areas over time and the decrease in the average size of the patches, the fragmentation of the agricultural areas has been more common. The least change was in the water bodies. In line with the findings obtained, sustainable planning and land use suggestions for land use were presented.

Keywords: CORINE, landscape metrics, land use/land cover, Trabzon.

Trabzon İlinin Mekânsal ve Zamansal Arazi Kullanımı/Arazi Örtüsü Değişimlerinin (1990-2018) CORINE Haritaları ve Peyzaj Metrikleri Kullanılarak İncelenmesi

Öz: Bu çalışmada; Trabzon ilinin 1990-2018 yılları arasında 28 yıllık dönemde nüfus artışıyla birlikte zamansal ve mekânsal olarak meydana gelen arazi örtüsü/arazi kullanımındaki değişimlerin CORİNE haritaları ve peyzaj metrikleri ile analiz edilerek değerlendirilmesi amaçlanmaktadır. Çalışma kapsamında, 1990, 2000, 2006, 2012 ve 2018 yıllarına ait CORİNE haritaları kullanılarak zamansal değişim analizi gerçekleştirilmiştir. Trabzon ilinde, CORINE sınıflandırma sistemine göre birinci düzeyde toplamda 4 ana grup tespit edilmiş olup üçüncü düzeyde 1990 yılına ait 19, 2000 yılına ait 20, 2006 yılına ait 24, 2012 ve 2018 yıllarına ait 26 arazi örtüsü/alan kullanımı sınıfı tespit edilmiştir. 28 yıllık süreçte en çok farklılaşmanın tarım alanları sınıfında meydana geldiği görülmüştür. Ayrıca çalışmada sınıf alanı (CA), leke sayısı (NumP), ortalama leke büyüklüğü (MPS), kenar yoğunluğu (ED), toplam kenar (TE) ve ortalama şekil indeksi (MSI) metrikleri ArcGIS'in Patch Analyst eklentisi aracılığıyla hesaplanmıştır. Meydana gelen değişimler incelenmiştir. Buna göre, geçen 28 yıllık süre içerisinde insan faaliyetlerinin ve nüfusun artmasına bağlı olarak yapısal alanların büyüklüğünün artmasıyla ormanlık ve yarı doğal alanlar ile tarım alanlarının büyüklüğünde azalmalar olmuştur. Ayrıca, tarım alanlarının leke sayısının zaman içerisinde sürekli artması ve ortalama leke büyüklüklerinin sürekli azalmasından dolayı tarım alanlarında parçalanma daha fazla yaşanmıştır. En az değişim ise su kütlelerinde olmuştur. Elde edilen bulgular doğrultusunda arazi kullanımına yönelik sürdürülebilir planlama ve alan kullanım önerileri sunulmuştur.

Anahtar kelimeler: Arazi Örtüsü/Arazi Kullanımı, CORINE, Peyzaj Metrikleri, Trabzon.

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INTRODUCTION

After the Industrial Revolution in the world, and in Türkiye after the 1950s, rapid population growth in cities, unplanned housing and urbanization movements without infrastructure are observed with the development of technology. Since people use natural resources directly or by processing in order to maintain their lives and create livable environments, they have started to put pressure on the landscape texture. According to Keleş et al. (2008), as a result of this pressure, the natural balance has deteriorated, causing various environmental problems such as environmental pollution and reduction of biodiversity. These problems negatively affect ecosystem health both locally and globally, and show that natural and cultural resources are in danger of extinction (Yetişen et al., 2022).

The most effective tool for ensuring the sustainability of natural and cultural resources is the planning process based on the functioning and connectivity of the landscape (McHarg 1969, Ndubisi 2002, Steiner 2000). Landscape is a mosaic formed by the combination of structurally different natural (climate, geology, geomorphology, hydrology, soil, topography, vegetation, wildlife and biodiversity) and cultural (settlement areas, agricultural areas, transportation, historical and archaeological sites and other human-created elements) components (Forman, 1995; Wascher, 2004; McGarigal et al., 2009). The structure of the landscape is constantly changing and reshaped depending on natural, cultural and social factors (Lindenmayer & Fischer, 2006; Erdoğan et al., 2014; Çorbacı & Dönmez, 2019).

Land cover (LC) refers to the physical features of the land such as natural vegetation, soil layer, water and all other human structures on the surface of the land, while land use (LU) refers to how humanity benefits from the land cover (Karaali et al., 2020; Hussain et al., 2022). Land Use and Land Cover (LULC) have been highly affected and changing due to human activities in recent years (Hussain et al., 2022). This situation greatly affects the landscape structure, ecosystem processes, biodiversity, habitat structure, hydrology and climate characteristics. LULC changes also determine global change (Turner et al., 1993; Verburg et al., 2009; Esbah et al., 2010). LULC changes can occur in line with rapid urbanization movements, availability of resources, climate fluctuations, socioeconomic factors and human needs (Turan et al., 2020; Topal, 2022).

Many scientific studies have been carried out by different professional disciplines about the changes in the land cover due to population growth and its effects on the LULC change (Shehu et al., 2023; Khan et al., 2023; Gaur & Singh, 2023; Eren & Cengiz Taşlı, 2023; Aydın & Eker, 2022; Aksoy et al., 2022; Ojeda Olivares et al., 2019; Oğuz & Zengin, 2011). In particular, decisions are needed regarding plans to protect urban wildlife, biodiversity, water resources and vegetation corridors (Yetişen et al., 2022). Because decisions about land and land cover can affect how much climatic characteristics will change in a cause-and-effect relationship and the situations that natural ecosystems will face (Brown e al., 2014). In this context, LULC change analyses are generally used to study environmental degradation and control unplanned development (Aksoy et al., 2022).

The types of land cover and their regional distributions are among the basic data needed for land planning studies (Kahya et al., 2010). In this direction, landscape planning studies are closely related to LULC and one of the most important goals of landscape planning studies is to determine the change in LULC classes (Ünlükaplan & Karagöz, 2022). Monitoring and understanding these changes is the most effective way to evaluate landscape mechanism. Thus, negative effects on natural and cultural landscape resources can be reduced (Demir & Demirel, 2016). For this reason, LULC maps are often used in the study of landscape structure. LULC maps are important in that they are one of the most important landscape indicators that reflect the spatial representation of categorical geographical units in the landscape (Karaali et al., 2020). As a matter of fact, in the European Landscape Convention, it is emphasized that it is important to determine the changes in landscapes over time in order to determine the sustainability of landscapes, to protect their diversity, to determine natural resources and to determine landscape types, in the planning and management of the landscape (Ünlükaplan & Karagöz, 2022). In this regard, examining the current LULC situation with reliable and sufficient LULC information is one of the basic requirements in terms of providing social, economic and environmental results in terms of land management. It plays an important role in the timely and accurate detection of changes in the landscape structure, the effective use and management of resources, making appropriate decisions for the future, and understanding the interaction between natural landscape components and people. According to Turner et al. (1989), Herold et al. (2005), many landscape metrics have been developed to explain the changes in landscape structure on the basis of fractal geometry. These developed metrics are criteria for numerically understanding the landscape structure and function and can be measured at the class level (Turner et al., 2001). Landscape metrics, which are also used for a better understanding of landscape change processes, are generally calculated at three levels: landscape mosaic (whole landscape), landscape classes and landscape patches (Botequilha Leitão et al., 2006). Recently, remote sensing (RS) data such as aerial photographs, satellite images, plans and maps and Geographic Information Systems (GIS) methodologies have been widely used in determining landscape structure changes (Jensen, 1996; Meffe & Carroll, 1997; Bayar & Karabacak, 2017; Turan et al., 2020; Hussain et al., 2022; Ünlükaplan & Karagöz, 2022). In this context, the CORINE database, which was created with remote sensing and geographic information systems, contains some errors in detail classes, but when evaluated on the basis of main classes, it is very valuable to give an idea about the land cover of Türkiye (Bayar & Karabacak, 2017).

According to the data of the Turkish Statistical Institute (TUIK), LULC also changed depending on the population growth between 1950 and 2000 in Türkiye (Aydın & Eker, 2022). Trabzon province is one of the largest provinces in the northeast of Türkiye and is one of the settlements where rapid population growth and intense urbanization movements are observed. Trabzon province is among the settlements where LULC tends to change rapidly due to the intense pressure of urbanization due to rapid population growth in both urban and rural areas, urbanization, industrial and tourism activities, and the decrease in productive agricultural areas (Çolak & Memişoglu, 2017).

In this context, the aim of this study is to analyze and evaluate the temporal and spatial changes in LULC in Trabzon with the population increase in the 28-year period between 1990-2018 with CORINE Land Cover (CLC) maps and landscape metrics. Within the scope of the study, land cover changes were monitored using Remote Sensing (UA) and Geographic Information Systems (GIS), and temporal variation analysis was performed using CORINE Land Cover (CLC) maps of 1990, 2000, 2006, 2012 and 2018. The changes that occurred were examined by using landscape metrics. In line with the findings obtained, sustainable planning and land use suggestions were made for land use.

MATERIAL AND METHOD

Study Area and Data: Trabzon, the 27th most populous cities of Türkiye, is located in the Eastern Black Sea Region of the Black Sea Region. Trabzon city is located between 39^0 07' 43,8'' and 40^0 30' 15,5'' latitude east and 40^0 31' 31,3'' and 41^0 06' 27,5'' latitude north. The total area of Trabzon city is 466,400 hectares, of which 22% is agricultural area, 26% is pasture, 44% is forestland and 8% is non-cultural land. It has 18 districts (URL-1, 2023; URL-2, 2023). Trabzon province was established on a sloping plateau and has few flat areas. A distorted urbanization has emerged as a result of the inefficient use of lands due to the effect of topography in the province. This situation has caused the concretization of the coastline and the air flow does not reach the city effectively as a result of the construction taking place parallel to the sea. In addition, the opening of river valleys to settlement also caused floods and overflows to be more dangerous (Kadıoğlu, 2011). These problems also negatively affect the sustainable development of Trabzon province (Sesli et al., 2009). The population of Trabzon province was 143,941 in 1990 and increased by 4.9% in 2000 to 214,949. The population of the province was 735,401 in 2006. The province gained metropolitan municipality status with the law numbered 6360, which entered into force in 2012, and the population of the province was 757,898. With an increase of 8.3% in the last 6 years, the population of the province was 807,903 in 2018 and the population density was 173 people/km^2 (TUİK, 2019). The study area consists of 18 districts, namely Ortahisar (Central), Akcaabat, Arakli, Arsin, Besikduzu, Carsibasi, Caykara, Dernekpazarı, Duzkoy, Hayrat, Koprubası, Macka, Of, Surmene, Salpazarı, Tonya, Vakfikebir and Yomra, located within the borders of Trabzon province (Figure 1).

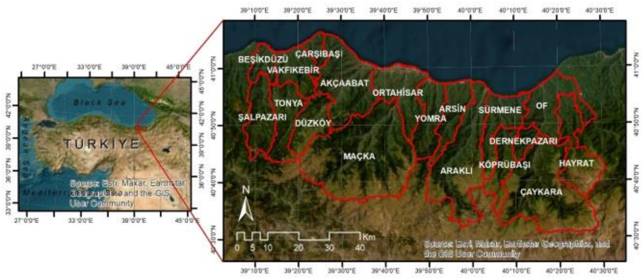

Figure 1. Study area

Methodology: In determining the LULC changes in Trabzon province, the maps of the CORINE land cover based on the classification system created by the European Environment Agency were used, published in 1990, 2000, 2006, 2012 and 2018. The data obtained in the ETRS_1989_LAEA coordinate system were processed in the ArcMap 10.8 software environment and the changes in the land cover were determined. Landscape metrics were calculated through the Patch Analyst module that can be added to ArcMap software. In the study, CA-Class Area, NumP-Number of Patches, MPS-Mean Patch Size, ED-Edge Density, TE-Total Edge and MSI-Mean Shape Index metrics were calculated. These metrics were used to evaluate the land use/land cover changes of Trabzon province between 1990-2018. The study was based on the first and third levels of the CORINE system, which classifies land covers at three different levels. At the first level, the lands are divided into 5 main classes (artificial surfaces, agricultural areas, forest and seminatural areas, wetlands, water bodies), and 44 subclasses at the third level. With the CORINE land classification, 4 main classes at Level 1 and 26 subclasses at Level 3 were determined for Trabzon province

FINDINGS

Map Production According to CORINE Classification: CORINE standard land use/land cover classification consists of 5 main classess and 44 subclasses of land use/land cover classes in a three-level hierarchical structure. In the classification, 5 different classes are defined at level 1, 15 at level 2, and 44 different classes at level 3 covering all types of land cover, and these 3 levels of 44 class nomenclatures are the same for all countries. The smallest mapping unit is 25 hectares and the standard mapping scale is 1:100.000 (Steenmans & Bergström, 1998).

Based on the LULC data created according to the CORINE classification system in the research, 19 Level 3 LULC classes from 1990, 20 from 2000, 24 from 2006, 26 from 2012, and 26 from 2018 were determined within the borders of Trabzon province (Table 3). According to the LULC area data obtained from the CORINE database in Trabzon, among the main groups (artificial surfaces, agricultural areas, forest and seminatural areas, water bodies), that is, at the Level 1, the areas with the highest LULC change between 1990-2018 are agricultural areas. In terms of change in 28 years, agricultural areas are in the first place in terms of areal size with 50,730.02 ha. This is followed by forest and seminatural areas with 23,777.29 ha, water bodies with 2,081.83 ha, and artificial surfaces with 119,19 ha, respectively (Table 1 and Figure 2).

Table 1. Spatial distributions of CORINE Level 1 LULC change in Trabzon province between 1990-2018.

LULC Area Change_1990_2018	Area (ha)	Toplam (ha)
No change	387.982,84	387.982,84
Artificial surfaces - Agricultural areas	108,58	
Artificial surfaces - Forest and seminatural areas	3,11	119,19
Artificial surfaces - Water bodies	7,50	
Agricultural areas - Artificial surfaces	2.994,32	
Agricultural areas - Forest and seminatural areas	47.637,37	50.730,02
Agricultural areas - Water bodies	98,33	
Forest and seminatural areas - Artificial surfaces	395,66	
Forest and seminatural areas - Agricultural areas	23.381,63	23.777,29
Forest and seminatural areas - Water bodies	39,10	
Water bodies - Artificial surfaces	534,46	
Water bodies - Agricultural areas	1.077,69	2.081,83
Water bodies - Forest and seminatural areas	469,68	

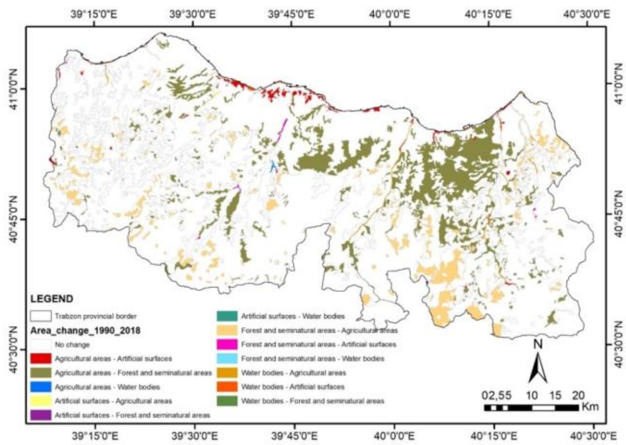

Figure 2. CORINE Level 1 LULC exchange classes of the province of Trabzon between 1990-2018.

In the province of Trabzon, the most common LULC class according to all levels is the pastures, which is included in the agricultural fields' category with the 2.3.1 classification code. Pastures are areas of dense grass cover that are mainly used for grazing and are flooded at certain times of the year (ETC/LC, 1995; Polat & Yalçın, 2020). These areas are actually the main pastures on the provincial land. These areas correspond to meadows near streams where the groundwater level is high; they are close to permanent settlements and cultivated areas. Although partial agricultural activities are encountered in the pasture areas, which are considered as grassland with a farm structure, sometimes animal feed (hay, etc.) is also obtained from these areas (Bossard et al., 2000; Harmanşah, 2018). There has been an increase in pasture areas with the classification code of 2.3.1 in recent years. The lands in this class in the study area had an area of 730.63 ha in 1990 and a proportional value of 0.16%. Pasture areas increased by 26,425.99 ha in 2018 and reached an area of 27,156.62 ha and a proportional value of 5.84% (Table 2). Pasture areas, which have an important place in terms of livestock, constitute 26% of the total area of 466,400 ha of Trabzon province. Pasture areas are located in rough and mountainous terrain due to the topographic characteristics of the province. Although this situation limits agriculture and livestock activities, it is seen that it has more fertile meadows and forest areas compared to other provinces. This class of lands is mostly located in the plateaus between 1600-2200 altitudes.

Broad-leaved forests, which are included in the forest and seminatural areas category with the 3.1.1 classification code, constitute the most common LULC class after pastures. Broad-leaved forest areas are areas where mainly broad-leaved trees, including shrubs and shrub species, are dominant in terms of vegetation form (ETC/LC, 1994; Polat & Yalçın, 2020). Among the forest areas in the study area, the areas with the largest area are generally broad-leaved forests formed by Eastern Black Sea Oak (*Quercus pontica*) and Eastern Beech (*Fagus orientalis*) species. The lands in this class in the study area had an area of 66,738.88 ha in 1990 and a proportional value of 14.36%. Broad-leaved forest areas increased by 18,358.4 ha in 2018, reaching 85,097.28 ha and a proportional value of 18.31% (Table 2). Among the coniferous forests included in the same category with the classification code 3.1.2, the forest areas with the largest area usually consist of the following species: Caucasian spruce (*Picea orientalis*), Caucasian fir (*Abies nordmannianas*), Scots pine (*Pinus sylvestris*) and Eastern Alder (*Alnus glutinosa* var. *orientalis*). The lands in this class in the study area had an area of 25,774.82 ha in 1990 and a proportional value of 5.55%. Coniferous forest areas increased by 4,278.23 ha in 2018 and reached 30,053.05 ha and a proportional value of 6.47% (Table 2).

Natural grassland, which are included in the category of shrub and/or herbaceous vegetation associations and defined by the classification code 3.2.1 in the CORINE database, are in the third place within the province land in 1990 with an area of 59,556.81 ha and a proportional value of 12,81%. There was an increase of 12,279.69 ha in these areas between 1990-2018 (Table 2). According to the areal value of 71,836.50 ha and the increase of 15,46% in Natural grassland in 2018, bare rocks with a classification code of 3.3.2 have been replaced by Natural grassland since 2012.

According to ETC/LC (1994), natural grasslands are defined as in areas with rough, scattered and uneven terrain where human intervention is limited, where at least 50% of the land surface is covered with herbaceous vegetation and rocky areas, thorny wild shrubs, grasslands with low grass yield, including covers such as shrubs and heather. The reason for such a high (12,279.69 ha) increase in these lands is that the human intervention on the pastures is partially limited and the use of pastures for livestock activities in the province is taken under control. In addition, it is seen that natural grassland areas are concentrated in the forest areas in Düzköy, Maçka, Araklı, Köprübaşı, Çaykara and Hayrat districts (Figure 3). This situation has emerged as a result of the pressure of forest villagers on forest areas, and some of the forest areas have become natural grassland. These and similar situations have led to an increase in natural meadows on the provincial land.

Heterogeneous agricultural areas are lands where various annual crops, pastures and permanent crops are found side by side (ETC/LC, 1995; Polat & Yalçın, 2020). Agricultural areas with scattered houses and garden sheds used for growing fruits and vegetables, and hobby gardens (city gardens) located near rural or urban settlements are included in this class (Bossard et al., 2000). There has been an increase of +9,926.32 ha in the 28-year period in these lands, which have the 2.4.2 classification code in the study area. Complex cultivation patterns had an area of 7,737.73 ha and a rate of 1.66% in 1990. Then, with an increase of +9,926.32 ha, it had an area of 17,664.05 ha and a rate of 3.8% in 2018 (Table 2). These LULC areas appear to be located near rural and/or urban areas (Figure 3).

Agricultural areas with natural vegetation are areas with arable orchards or vineyard plots smaller than 25 ha, where agricultural activities are carried out within the natural vegetation (URL-3, 2023). These areas, defined by the 2.4.3 classification code, had an area of 207,378.81 ha and a rate of 44.62% in 1990. By 2018, these areas had an area of 25,629.75 ha and a rate of 5.51%, with a decrease of 181,749.06 ha (Table 2). The main reason for such a high (181,749.06 ha) decrease in these lands is human intervention. These areas are the LULC class with the highest areal decrease in Trabzon province according to all levels.

The second LULC class in the province with the highest areal decrease according to all levels is the transitional woodland/shrub areas defined with the 3.2.4 classification code in the CORINE database. These areas were evaluated as areas where woods or coppice lands where tree cutting was carried out with certain periods were reforested (Sarı & Özşahin, 2016; Polat & Yalçın, 2020). These areas, which corresponded to 4.72% of the study area with 21,937.43 ha in 1990, decreased to 7.435.79 ha in 2018 and decreased to 3.2% (Table 2). In the province, these LULC areas are commonly seen in the mountainous areas of Beşikdüzü, Şalpazarı, Tonya, Vakfıkebir, Akçaabat, Maçka, Yomra, Arsin, Araklı, Köprübaşı, Çaykara, Of, Hayrat districts (Figure 3).

The third LULC class in the province with the highest area reduction according to all levels is the fruit trees and berry plantations defined by the 2.2.2 classification code. It was observed that these land use/land cover areas were not included in the study area between 1990-2000. These areas have an area of 122,988.15 ha and a rate of 26.46% in 2006. By 2018, it had an area of 119,209.24 hectares and a rate of 25.65% with a decrease of 3,778.91 ha (Table 2). In the course of time, there has been a decrease in these areas due to activities such as housing, road and building construction with human intervention.

Sparsely vegetation areas are areas where the vegetation rate is between 10-50% and which have scattered, woody and semi-woody steppe vegetation and unproductive soils at high altitudes due to erosion and late snowmelt (ETC/LC, 1995; URL-3, 2023). Areas covered with sparsely vegetation, which are included in the forest and seminatural areas category with the 3.3.3 classification code, had an area of 5,351.94 ha and a rate of 1.15% in 1990. As of 2018, these areas had an area of 3.002.99 ha and a rate of 0.65% with a decrease of 2,348.95 ha. With the increasing anthropogenic effect in recent years, forest areas have been destroyed and decreased. A decrease of 2,348.95 ha in areas covered with sparsely vegetation over a 28-year period shows the extent of the destruction in forested areas (Table 2).

Water courses are natural or artificial waterways, including channels used as drainage channels, and must have a minimum width of 100 m (URL-3, 2023). Water courses, which are included in the water bodies category with the 5.1.1 classification code, had an area of 2.150.59 ha and a rate of 0.46% in 1990. By 2018, these areas had an area of 523.21 hectares and a rate of 0.11% with a decrease of 1.627.38 hectares (Table 2). The reason for this decrease in the 28-year period is the human intervention in natural resources due to the need for shelter due to population growth. Level-3 LULC maps of Trabzon province for the years 1990, 2000, 2006, 2012 and 2018 are shown in the Figure 3.

Calculating landscape metrics using Patch Analyst for ArcGIS: The metric values calculated in order to understand and describe the change in the artificial surfaces, agricultural areas, forest and seminatural areas, water bodies classes determined at the first level according to the CORINE classification system in Trabzon between the years 1990-2018 are given in Table 3.

The CA index is defined as the dominance and dominance index (Eren & Cengiz Taşlı, 2023). When the values obtained in Table 3 are examined, the landscape pattern with the highest CA in the research area in 1990 is forest and seminatural areas with 243766 ha, agricultural areas with 215847,2 ha, water bodies with 2908.03 ha and artificial surfaces with 2250,410085 ha designated areas. This ratio was determined as forest and seminatural areas with 243722,5 ha, agricultural areas with 215143,6 ha, artificial surfaces with 3055.034564 ha and water bodies with 2850,271 ha in 2000. In 2006; forest and seminatural areas with 267042,5 ha, agricultural areas with 192055.7 ha, artificial surfaces with 4518,067065 ha and water bodies with 1155,623 ha. In 2012, forest and seminatural areas with 268240 ha, agricultural areas with 189996,9 ha, artificial surfaces with 5570,802476 ha and water bodies with 964,4912 ha. When these rates come to 2018, it is seen as forest and seminatural areas with 268060,2 ha, agricultural areas with 189688,2 ha, artificial surfaces with 6059.134124 ha and water bodies with 964,4912 ha. It is seen that the most change in the last 28 years has been experienced in artificial surfaces. Depending on the increase in the artificial surfaces over time, there have been decreases in forest and seminatural areas and agricultural areas. In this process, forest and seminatural areas, which have the highest rate on the basis of years, constitute the dominant land cover class in the area.

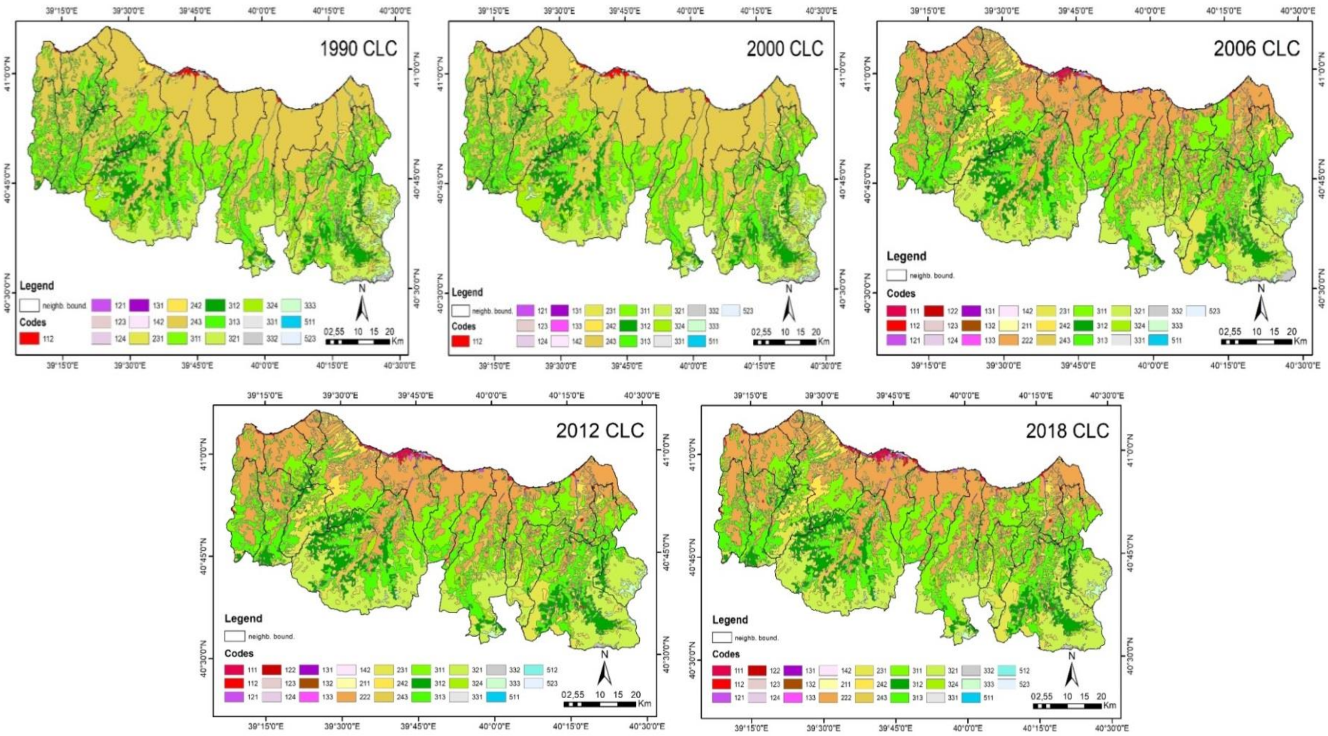

Figure 3. CORINE Level 3 land cover classes of Trabzon province in 1990, 2000, 2006, 2012 and 2018.

Table 2. Areas covered by CORINE land cover classes in Trabzon province in 1990, 2000, 2006, 2012 and 2018 and their percentage values.

CORİNE Level-1	CORİNE Level-3 Codes	1990 Percent (%)	1990 Area (Ha)	2000 Percent (%)	2000 Area (Ha)	2006 Percent (%)	2006 Area (Ha)	2012 Percent (%)	2012 Area (Ha)	2018 Percent (%)	2018 Area (Ha)
1. Artificial Surfaces	**111**	-	-	-	-	0,27	1.266	0,38	1.766	0,39	1.832
	112	0,39	1.835,10	0,5	2.323,52	0,42	1.930,57	0,43	1.994,80	0,5	2.346,01
	121	0,01	24,75	0,03	127,16	0,08	352,06	0,11	506,6	0,12	562,67
	122	-	-	-	-	-	-	0,05	225,65	0,05	225,65
	123	0,01	67,32	0,02	77,43	0,06	292,09	0,05	224,29	0,05	224,29
	124	0,02	100,03	0,03	137,41	0,03	147	0,03	133,48	0,03	133,48
	131	0,02	86,73	0,02	97,03	0,03	133,03	0,06	259,76	0,07	326,54
	132	-	-	-	-	0,01	36,95	0,01	37,31	0,01	37,31
	133	-	-	0,03	128,98	0,04	196,96	0,08	365,68	0,07	314,05
	142	0,03	136,49	0,04	163,52	0,01	57,95	0,01	57,25	0,01	57,25
2. Agricultural areas	**211**	-	-	-	-	0,01	28,36	0,01	28,58	0,01	28,58
	222	-	-	-	-	26,46	122.988,15	25,72	119.554,32	25,65	119.209,24
	231	0,16	730,63	0,15	693,64	6,21	28.881,59	5,84	27.156,79	5,84	27.156,62
	242	1,66	7.737,73	1,61	7.491,69	3,38	15.723,85	3,81	17.715,70	3,8	17.664,05
	243	44,62	207.378,81	44,53	206.958,29	5,26	24.433,71	5,5	25.541,54	5,51	25.629,75
3. Forest and seminatural areas	**311**	14,36	66.738,88	14,99	69.664,20	18,86	87.667,95	18,37	85.358,97	18,31	85.097,28
	312	5,55	25.774,82	5,53	25.711,07	6,23	28.932,45	6,46	30.020,46	6,47	30.053,05
	313	13,41	62.347,64	13,58	63.134,89	13,39	62.225,13	13,56	63.012,27	13,54	62.949,99
	321	12,81	59.556,81	12,81	59.556,59	14,82	68.865,17	15,47	71.900,77	15,46	71.836,50
	324	4,72	21.937,43	3,91	18.184,29	3,08	14.327,89	3,08	14.325,75	3,12	14.501,64
	331	0,1	482,24	0,12	543,29	0,06	262,91	0,04	164,87	0,04	164,87
	332	0,34	1.576,21	0,34	1.576,21	0,33	1.515,33	0,1	453,93	0,1	453,93
	333	1,15	5.351,94	1,15	5.351,98	0,7	3.245,66	0,65	3.002,99	0,65	3.002,99
5. Water bodies	**511**	0,46	2.150,59	0,46	2.150,56	0,14	656,54	0,11	523,21	0,11	523,21
	512	-	-	-	-	-	-	0,02	101,34	0,02	101,34
	523	0,16	758,24	0,15	699,71	0,11	499,08	0,07	339,94	0,07	339,94

The NumP value is the fragmentation metric, and an increase in this value indicates an increase in fragmentation. The MPS value, which is an index based on the number of patch in a class and landscape index, expresses the area of each patch that makes up a landscape mosaic (Fichera et al., 2012; Kesgin Atak, 2020). A landscape in which the mean patch size is smaller for the type of patch studied is considered more fragmented than another landscape. When the changes in the number of patches (NumP) and average patch size (MPS), which are the most important indicators of fragmentation, are examined, it is seen that the number of patches (NumP) in the agricultural area class constantly increases over time, while the average patch size (MPS) decreases continuously. Accordingly, when the values in Table 3 are examined, it is seen that the number of patches in agricultural areas increased from 3 to 5 between 1990-2006 and remained the same as 5 between 2006-2018. It is seen that while the average patch size in agricultural areas was 71949,06 ha in 1990, it was 37937,65 ha in 2018 and decreased over time. This is an indication of the fragmentation of agricultural areas. The number of patches in artificial surfaces increased from 6 to 10 between 1990-2006 and remained the same as 10 between 2006-2018. While the average patch size in artificial surfaces was 375,068348 ha in 1990, it increased to 605,913412 ha in 2018 and increased over time. Although the number of patches in the forest and seminatural area class remained the same as 8 in 28 years, the average patch size in forest and seminatural areas was 30470,75 ha in 1990, while it became 33507,53 ha in 2018. In the water bodies class, the number of patches increased to 2 between 1990-2006 and to 3 between 2012-2018. While the average patch size in water bodies was 1454,415 ha in 1990, it became 321,4971 ha in 2018. When these values are considered and interpreted together, it is seen that the fragmentation in agricultural areas is more due to the continuous increase in the number of patches in the agricultural areas over time and the continuous decrease in the average size of the patches.

Edge density (ED) is obtained by dividing the total edge length of the relevant land use class by the total area. In the initial stages of the division, the amount of edge is expected to increase relative to the total area (Pal et al., 2021). The ED value of the habitat parts in the study area increased by 2.35% in the artificial surfaces class between 1990 and 2018. The total edge density in agricultural areas increased by 18.7%. While the total edge density decreased by 6.5% between the years 1990-2000 in forest and seminatural areas, it increased by 18.8% between the years 2000-2006, and decreased again by 1.3% between the years 2006-2012. It increased again by 0.8% between 2012 and 2018 (Table 3). The total edge density in water bodies decreased by 2%. While the greatest change was observed in agricultural areas with an increase of 18.7%, the least change was experienced in water bodies with a decrease of 2%. Human activities are effective in the change of total edge lengths depending on ED.

Table 3. Landscape metric values for different land use/land cover classes.

Years	CORİNE Level-1	Landscape metrics*					
		MSI (km)	**TE (m)**	**ED (m/ha)**	**MPS (ha)**	**NumP**	**CA (ha)**
1990	1. Artificial Surfaces	3,639895	162245,3705	0,349086	375,068348	6	2250,410085
2000		4,099043	209961,2378	0,451752	436,433509	7	3055,034564
2006		4,588956	375182,7148	0,807241	451,806707	10	4518,067065
2012		5,040354	441738,8722	0,950442	557,080248	10	5570,802476
2018		5,123133	468553,2527	1,008135	605,913412	10	6059,134124
1990	2. Agricultural Areas	13,17155	3785730	8,145342	71949,06	3	215847,2
2000		12,94216	3773019	8,118009	71714,54	3	215143,6
2006		16,55052	6143344	13,21798	38411,13	5	192055,7
2012		16,91481	6209681	13,3607	37999,38	5	189996,9
2018		16,952008	6223085	13,38954	37937,65	5	189688,2
1990	3. Forest and seminatural areas	15,64229	8218496	17,68284	30470,75	8	243766
2000		15,10691	7915704	17,03139	30465,32	8	243722,5
2006		14,96093	8438917	18,15712	33380,31	8	267042,5
2012		14,71409	8400108	18,0736	33530	8	268240
2018		14,75057	8422325	18,12141	33507,53	8	268060,2
1990	5. Water bodies	21,28786	543252	1,168856	1454,415	2	2908,83
2000		21,56692	539486	1,160756	1425,135	2	2850,271
2006		18,8465	313070	0,673599	577,8114	2	1155,623
2012		13,71816	278916,2	0,600114	321,4971	3	964,4912
2018		13,71816	278916,2	0,600114	321,4971	3	964,4912

***** MSI: Mean Shape Index, TE: Total Edge, ED: Edge Density, MPS: Mean Patch Size, NumP: Number of Patches, CA: Class Area.

In landscape measurement metrics, the increase in the ED experienced in agricultural areas between 1990-2018 caused the fragmentation of agricultural areas by transforming them into artificial surfaces due to the increase in human activities and population, with the province becoming a metropolitan city in 2006. According to Table 3, it is seen that the TE value increased regularly between 1990 and 2018 in artificial surfaces and decreased regularly in agricultural areas. While there was a decrease between 1990-2000 in forest and seminatural areas, it is seen that there was an increase between 2000-2006, a decrease again between 2006-2012, and an increase again between 2012-2018. On the other hand, while there was a regular decrease in water bodies between 1990-2012, it is seen that there was no change between 2012-2018.

The total edge (TE) value correlates with the MSI value. The increase in the TE value also caused the MSI value to become irregular. The higher the MSI value, the more complex the stain geometrically. The fact that the MSI value moves away from 1 indicates that the parts move away from the shape of a non-uniform, clear square or circle. The MSI value equals 1 when all patches are circular or square (McGarigal & Marks, 1995; McGarigal et al., 2009; Mohamed et al., 2021). When the MSI values calculated for the patch shape in Table 3 are examined, it is seen that there was an increase of 5.29% in artificial surfaces and 13.5% in agricultural areas between 1990 and 2018. It is seen that there is a decrease of 3.18% in forest and seminatural areas, and a decrease of 27% in water bodies. Accordingly, the biggest change in the 28-year period was experienced in the shape indices of agricultural areas and water bodies. In terms of the TE value, which is related to the MSI value, the greatest change was observed in agricultural areas with an increase of 18.7%, while the least change was experienced in water bodies with a 2% decrease. Depending on both MSI and ED values, human activities are very effective in the complexity of the patches and the change in the total edge lengths.

DISCUSSION AND CONCLUSION

In Trabzon, according to the CORINE classification system, a total of 4 main groups (artificial surfaces, agricultural areas, forest and seminatural areas, water bodies) were identified at the first level, and it was seen that the most common land use/land cover category among these groups was agricultural areas. At the third level in the province, 19 land use/land cover classes were determined for 1990, 20 for 2000, 24 for 2006, and 26 for 2012 and 2018. The land use/land cover category on the provincial land, which was 24 in 2006, increased to 26 in 2018 with the addition of areas related to ‘Road and rail networks and associated land’ and ‘Water bodies’.

Between 1990-2018 in Trabzon province, 2.1.1 (Non-irrigated arable land), 1.1.1 (Continuous urban fabric), 1.2.4 (Airports), 1.3.2 (Dump sites), 1.4.2 (Sport and leisure facilities) coded CORINE classes were determined to have very little spatial-proportional changes. The absence of significant changes in these areas is due to the lower anthropogenic impact intensity on the land use/land cover in the specified classes. As a result of analyzes made within the scope of the study, it was determined that a total of 125315,164 ha variation occurred in the land use/land cover classes determined according to the CORINE system in the province of Trabzon over a 28-year period. It was observed that the most differentiation occurred in the ‘Land principally occupied by agriculture, with significant areas of natural vegetation’ (-181.749.06 ha) defined by the 2.4.3 classification code. This is followed by ‘Pastures’ (+26.425.99 ha), defined by the classification code 2.3.1, respectively, 3.1.1 ‘Broad-leaved forest’ (+18.358.4 ha) defined by classification code, ‘Natural grassland’ defined by 3.2.1 classification code (+12.279.69 ha), ‘Complex cultivation patterns’ defined by 2.4.2 classification code (+9.926.32 ha), and it was observed that the Transitional woodland/shrub’ areas (-7,435,79 ha) defined by the 3.2.4 classification code followed.

In the study, CA, NumP, MPS, ED, TE and MSI metric values were also calculated in addition to the CORINE classification system in order to evaluate the land use/land cover changes of Trabzon province between 1990-2018. Accordingly, there has been a decrease in the size of forest and seminatural areas and agricultural areas due to the increase in the size of the artificial surfaces over the past 28 years. As the province became a metropolitan city in 2006, due to reasons such as road construction and the creation of residential areas due to the increase in human activities and population, agricultural areas were transformed into artificial surfaces and caused more fragmentation within the landscape structure. In addition, due to the continuous increase in the number of patches in the agricultural areas over time and the decrease in the average size of the patches, the fragmentation of the agricultural areas has been more common. Between 1990-2018, the rate of fragmentation in agricultural areas was higher in 2018. The least change was in water bodies.

CONCLUSION

As a result, there have been some changes in the landscape pattern of Trabzon province. It is seen that these areas should be protected for the sustainability of agricultural practices specific to Trabzon. Changes that show in which direction the new settlement areas are moving are an important input for future planning studies. It is necessary to take measures against fragmentation in areas where natural habitat and biodiversity need to be protected, and to develop planning strategies with numerical data obtained on the possible consequences of spatial change. In line with the data obtained in the study, it is suggested that the positive and negative aspects of the land use of Trabzon province should be analyzed and the positive practices should be continued and the negative and wrong practices should be noticed and improved.

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