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Multilevel scientific approach to impacts of global warming on urban areas, energy transition, optimisation of land use and emergency scenario

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An evaluation on the change of natural areas: the case of Eastern Black Sea settlements

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Abstract
Urbanization has a significant impact on social, economic and environmental sustainability. Dynamic urban development and change processes affect both the natural and built environment. Recently, with the increase in urban population and the expansion of urban areas, the pressure on natural areas has increased. Understanding the relationships between natural and built environmental elements that depend on dynamic processes is important and necessary for the future development and management of urban areas. For this reason, the study aims to analyze land use/land cover changes depending on natural environmental elements in the settlements of the Eastern Black Sea Region for a period of approximately 20 years. Considering the heterogeneous structure of the settlements, a multivariate process was followed at the district level. The data set of the study was provided by CORİNE and TUIK and Two-Step Clustering Analysis was used as the method. As a result of the study, the changes over time of the districts in similar and different clusters according to their natural environment components were evaluated by comparative discussion. The results will be useful and guiding in providing input to planning decisions regarding the similarities and differences of districts-provinces and sub-regions based on natural environmental components.

Keywords
Natural areas; Land-use pattern and change; Two-step cluster analysis; Eastern Black Sea Region-Turkey

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1. Introduction

Terrestrial ecosystems are important components of nature since they have biological and functional effects on climate regulation, the hydrologic cycle and as a source of natural resources to satisfy human needs. However, during the last 300 years, the ecosystems have been subject to accelerated processes of land use and cover changes (LUCC) (Jiménez et al., 2018). This has been identified as one of the main factors contributing to global environmental change (Magliocca et al., 2015; Turner et al., 2013; Verburg et al., 2015). Land change is the result of the interaction of political/institutional, economic, cultural, cultural, technological, natural/spatial drivers and the actors involved (Bürgi et al., 2004; Hersperger et al., 2010). The term 'land use' usually refers to the changes wrought on the surface of earth by way of increasing human activities. 'Land cover' refers to the physical manifestation of the surface of the earth; the distribution process of water, soil, vegetation or urban area arrangement (Fahad et al., 2020).

The factors influencing land use land cover change are complex and dynamic and vary from one place to another. These changes are primarily driven by natural and human-induced factors (Mobaraki, 2023). One of the most important human-induced factors is the increase in the urban population and the urbanization processes that develop due to this increase. International statistics show that the global population has increased rapidly over the last century and will continue to increase in the coming decades, albeit at a lower rate (Addae & Oppelt, 2019). And it shows that the global urban population will increase by up to 68% by 2050. With stronger urbanization expected in the coming years, cities will cover increasing areas of the earth's surface and will host the majority of the human population (Seto et al., 2012). The growth and development of urbanization in the last few decades, as well as the land use changes around and inside big cities have been considered as one of the most essential challenges of global sustainable development (Mobaraki, 2023). Land use and land cover changes following population growth and urbanization cause major current environmental problems such as widespread urban sprawl, land loss and degradation, climate change, vegetation loss, biodiversity loss, conversion of agricultural land, deforestation and ecosystems fragmentation (Jiménez, etc., 2018). As a result, ecosystems are also negatively affected by such destruction of nature and vegetation areas.

1.1 Theoretical Framework

Recent increases in urban populations and the expansion of urban areas have increased pressure on natural areas (UN, 2009). As urban areas expand, transform and envelop the surrounding landscape, they affect the environment at various spatial and temporal scales, such as climate change, loss of wildlife habitat and biodiversity, and greater demand on natural resources (Steffen et al., 2004). With the rapid increase in population and urbanization, especially since the mid-20th century, a number of ecological and environmental problems have emerged, such as the uncontrolled spread of construction lands, deterioration of habitat quality and landscape fragmentation (Han et al., 2015; He et al., 2014; Lei et al., 2016). Moreover, urban land change is not limited to the central city but includes many new urban-rural areas functionally connected to the city (Brenner & Schmid, 2015) and has many impacts on rural hinterlands (Bren d'Amour et al., 2016). This kind of changes therefore profoundly affects local and/or regional environment, which would eventually affect the global environment (Hegazy & Kaloop, 2015). At this point, open and natural/non-urbanized areas in and around the city affected by land changes are becoming increasingly important in terms of environment and quality of life. In many countries, open spaces are today regarded an integral part of land use planning decisions (Maruani & Amit-Cohen, 2007). Protection of open space is directly linked to the issue of urbanisation, making it one of the dominant planning topics in the developed World (Koomen et al., 2008). At this point, the current and future status of "open spaces" and "non-urbanized" areas, which are natural environments for sustainable urban development and development facing risks and challenges, is of great importance.

Open spaces are generally characterized by a low level of intervention that does not change their intrinsic "naturalness", and allows continuous functioning of the ecosystems and survival of nature and landscape

values. Open spaces, which are roughly divided into two different types: agricultural landscapes and natural areas, are also divided into two main categories according to their functions. These functions are the provision of recreation and other services to the community and the protection of natural values (Maruani & Amit-Cohen, 2007; Koomen et al, 2008). In addition, many natural resources provide society with ecological (e.g. protection of natural processes and resources, conservation of biodiversity) and environmental (e.g. maintaining air and water quality, improving the local microclimate) services, that are considered life-supporting systems (Maruani & Amit-Cohen, 2007).

Another natural environment feature, non-urbanised areas (NUAs) are part of agricultural and green infrastructures that provide ecosystem services (La Greca et al., 2011). These areas are semi-natural patches that represent the last remnants of nature in the urban context and play an important role in mitigating the consequences of climate change (Bowler et al., 2010; La Rosa & Privitera, 2013). As part of the agricultural and green infrastructure they provide ecosystem services, such as purification of air and water, mitigation of floods and droughts, re-generation of soil fertility, moderation of temperature extremes and enhancing of landscape quality (La Rosa & Privitera, 2013). Ecosystem services are the conditions and processes through which natural ecosystems and the species that compose them sustain and fulfill human life (Daily, 1997). Although ecosystem services are essential for sustaining the long-term well-being of societies, their quantity and quality are expected to continue to deteriorate in the coming decades (Millennium Ecosystem Assessment, 2005; Foley et al., 2005). There is growing evidence that natural environments – including green and open spaces – provide wide-ranging benefits for urban populations, referred to broadly as ecosystem services. These benefits are commonly referred to as ecosystem services (Douglas et al., 2019). Elements of the built environment represent a high level of intervention in the ecosystem, altering the landscape and interfering with natural processes, sometimes irreversibly. Interference can cause irreversible consequences or damage irreplaceable natural assets (Chavas, 2000). Therefore, under the impact of global ecosystem changes, coordinated development of all natural elements has become a top priority in maintaining ecological security (Gao et al., 2022). Therefore, as urban areas are expected to continue to grow in the future, planners and political decision-makers should carefully consider the role of non-urbanized areas in providing ecosystem services (La Greca et al., 2011). As a result, population increases, the urbanization phenomenon brought about by population growth and land use/land cover (LULC) changes seriously threaten sustainable resource use and global/regional environmental sustainability. Therefore, there is a need for appropriate interventions that can prevent the negative consequences of urbanization and ensure sustainable urban development. As Seto and Fragkias (2005) note, "characterizing and understanding the changing patterns of urban growth is critical given that urbanization will continue to be one of the major global environmental changes in the foreseeable future". In such a context, knowing the spatial-temporal pattern of urban growth, monitoring land cover change and revealing past trends will provide insights into future developments.

Based on all these, the aim of the study is to analyze the natural land cover changes of the settlements in the Eastern Black Sea Region - at the district level - depending on time and space. The study, which supports sustainable urban planning, evaluated the time-dependent changes of open spaces and non-urbanized areas. The year 2000 was set as the start year and 2018 as the end year, taking into account the availability of data. Changes in the natural environmental elements of settlements as a result of population growth and urbanization processes were examined with the help of classified maps. In such a context, knowing the spatio-temporal pattern of urban growth is crucial for formulating sustainable urban development policies that can mitigate the negative impacts of urbanization and ensure sustainable urban development.

2. Methodological framework

The physical process of urban land use change is often described as a change in the absolute area of urban space or a change in the rate at which other areas, such as agriculture, are converted to urban uses (Seto et

al., 2000). For any time period, the spatial arrangement of urban areas provides a snapshot of various economic, social, and political factors that influenced land-use decisions (Seto & Fragkias, 2005). Recently, innovative approaches to urban land use planning and management such as sustainable development and smart growth have been proposed and widely discussed (Kaiser et al., 1995; American Planning Association, 2002). Their application relies heavily on existing knowledge about the causes, chronology and impacts of urban change processes (Herold et al., 2005).

Knowledge of the land use/cover patterns of a region is one of the prerequisites for the planning and implementation of effective land use policies and schemes for sustainable regional development (Suthakar & Bui, 2008). Land use changes are a complex and dynamic processes that link together natural, economic, social and cultural factors in time and space (Koomen et al., 2008) and various tools are needed to understand and explain these processes (Hapugala, 2013). Geographic Information Systems (GIS) and remote sensing techniques provide effective tools in studying and monitoring land-use/land-cover change over space and time (Addae & Oppelt, 2019). Remote sensing can detect changes in land cover and land use and monitor the consequences of human and natural activity (Partheepan et al., 2023).

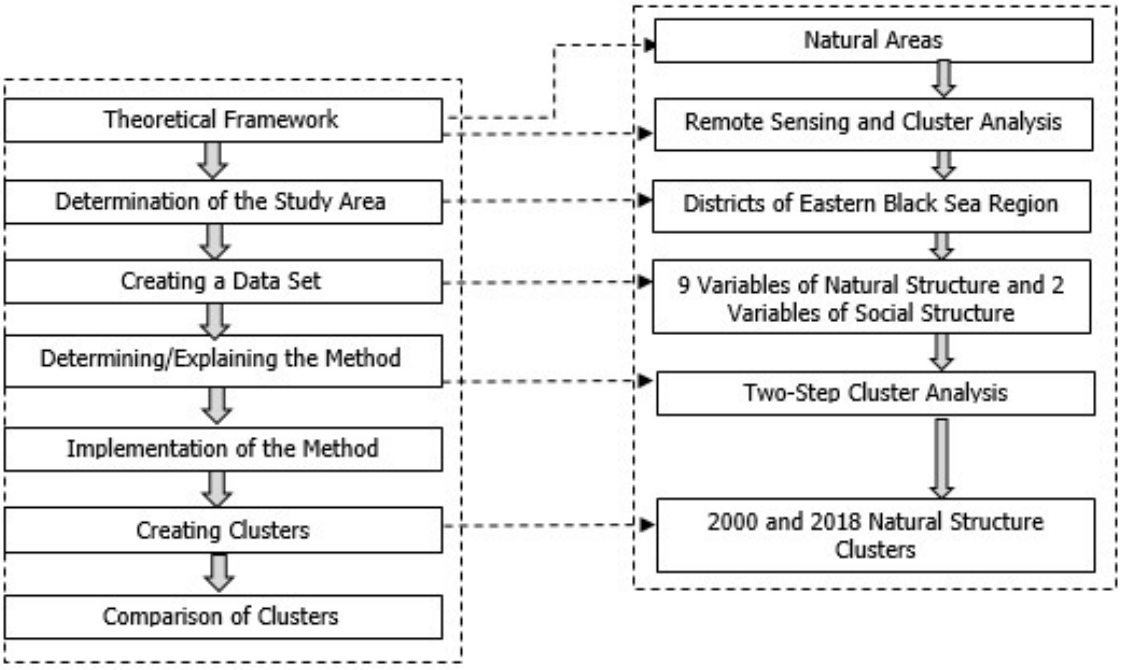

Fig.1 Study process and its application in the Eastern Black Sea Region

Remote sensing data highlight high temporal frequency land cover changes that are of great importance for earth system processes (Lambin et al., 2003). Remote sensing represents a major though still under-used source of urban data, providing spatially consistent coverage of large areas with both high geometric detail and high temporal frequency, including historical time series (Herold et al., 2005). Usually, land uses and urban growth in remote sensing involves the analysis of two registered, aerial or satellite multi-spectral bands from the same geographical area obtained at two different times (Hegazy & Kaloop, 2015). Monitoring land cover transformation can be accomplished by a simple comparison of successive land cover maps. In contrast, detection of subtle changes within land cover classes requires representation of land cover where surface attributes change continuously over time and space, at seasonal and interannual scales. Such an analysis aims at identifying changes that have occurred in the same geographical area between the two times considered (Radke et al., 2005). Remote sensing and Geographical Information Systems (GIS), when integrated with the tools of landscape ecology, can be used to investigate the changing spatial patterns of biodiversity.

A description of the shape, size and spatial arrangement of patches of vegetation in the landscape can be used to link the observed pattern with the ecological processes that may have generated it. Alongside spatial

scale, temporal scale is equally important when assessing the change of a landscape over time. Multi-temporal analysis based on remotely sensed data has played an important role in landscape ecology (Rocchini et al., 2006). The methodological framework consists of determining the study area based on the elements of the natural environment, creating the natural structure data set of the area and explaining the cluster analysis, which is the study method (Fig.1).

2.1 Study area

The Eastern Black Sea Region, one of Turkey's 12 regions according to the Statistical Regional Classification (Level-1), consists of 6 provinces (Artvin, Giresun, Gümüşhane, Ordu, Rize and Trabzon) and 79 districts. According to the 2017 Socio-Economic Development Index (SEGE) study, Trabzon ranks 26th, Rize 36th, Artvin 49th, Giresun 53rd, Ordu 60th, and Gümüşhane 64th among the provinces in the region (Fig.2).

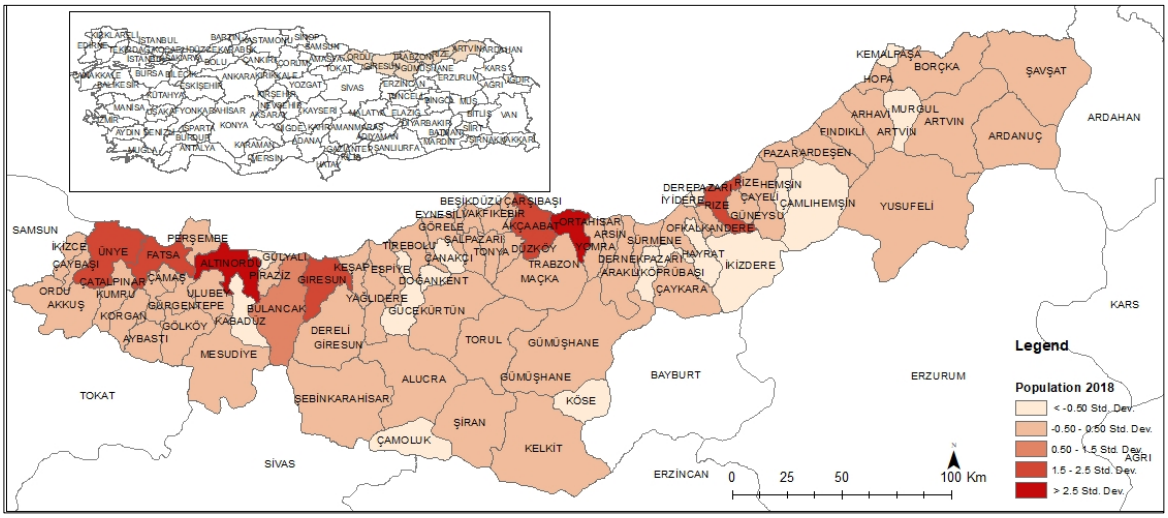

Fig.2 Location of the Eastern Black Sea Region and population size of settlements

As of 2023, 3.20% (2,733,265 people) of the country's population of approximately 85 million live in the Eastern Black Sea provinces. The country's population density, which was 77 people/km2 in 2018, became 78 people/km2 in 2023. While Artvin (23 persons/km2), Giresun (68 persons/km^2), Gümüşhane (23 persons/km^2) are below the national average, Ordu (130 persons/km^2), Rize (89 persons/km^2) and Trabzon (177 persons/km^2) are above the national average (TÜİK, 2023). According to the 2018 census; the average annual population increase in the region is 32.02 (per thousand) and the decrease in Gümüşhane province in 2018 is remarkable. All other provinces of the region are above the country average in this period. According to 2023 data the regional average is 15.94 (per thousand) and all provinces except Trabzon (7.71) are above the regional average (TÜİK, 2000-2018-2023).

The study area was chosen as the Eastern Black Sea Region due to the rich natural environmental elements of the region. According to 2000 values, 99.49% of the region consisted of "agricultural areas", "forest and semi-natural areas", "wetlands" and "water bodies" which can be defined as natural areas. With this ratio, the region ranked first in the country. The region has an important place in the country especially in terms of Forests and Semi-Natural Areas. The region also has the lowest Artificial area ratio in the country. According to 2018 data, the natural area ratio was 99.23% (4th in the country). In 2018, when evaluated in terms of natural environmental elements, there are 1,073,649 ha of agricultural areas, 2,422,571 ha of forest and semi-natural areas and 17,112 ha of water bodies in the region (Tab.1) (TÜİK, 2000-2018-2023).

	Regions	Artificial Areas(1)		Agricultural Areas (2)		Forests and Semi-Natural Areas (3)		Wetlands (4)		Water Bodies (5)		Total Ratio (%)	
		2000	2018	2000	2018	2000	2018	2000	2018	2000	2018	2000	2018
TR1	İstanbul	18.60	22.65	28.88	29.11	49.97	45.62	0.07	0.14	2.47	2.48	81.40	77.35
TR2	West Marmara	2.33	2.78	54.49	55.64	42.16	40.33	0.22	0.20	0.81	1.05	97.67	97.22
TR3	Ege	2.26	2.75	41.92	43.39	54.45	52.52	0.58	0.35	0.79	0.99	97.74	97.25
TR4	East Marmara	2.26	3.04	41.00	44.12	55.30	51.24	0.22	0.26	1.22	1.35	97.74	96.96
TR5	Western Anatolia	2.17	2.61	56.50	56.43	38.10	36.73	0.65	1.52	2.58	2.70	97.83	97.39
TR6	Mediterranean Sea	1.47	2.14	35.19	35.23	61.42	60.53	0.25	0.32	1.67	1.78	98.53	97.86
TR7	Central Anatolia	1.22	1.56	53.62	54.62	43.97	41.46	0.48	1.49	0.71	0.87	98.78	98.44
TR8	Western Black Sea	1.19	1.20	39.23	40.66	58.84	57.19	0.15	0.16	0.59	0.78	98.81	98.80
TR9	Eastern Black Sea	**0.51**	**0.77**	**28.91**	**30.32**	**70.15**	**68.42**	**0.00**	**0.00**	**0.43**	**0.48**	**99.49**	**99.23**
TRA	Northeast Anatolia	0.76	0.98	33.29	37.34	65.06	60.57	0.36	0.51	0.53	0.60	99.24	99.02
TRB	Middle East Anatolia	0.63	0.86	26.71	27.48	65.85	65.04	0.68	0.34	6.13	6.28	99.37	99.14
TRC	Southeast Anatolia	0.94	1.52	50.90	53.95	47.10	43.34	0.01	0.04	1.04	1.14	99.06	98.48

Tab.1 Land cover distribution of geographical regions of Turkey

2.2 The dataset

The dataset of the study, which aims to analyze land cover change due to natural environmental factors over time and space, consists of land cover/use variables obtained from the CORINE (Coordination of Information on the Environment) database/bank of Turkey. CORINE data includes land cover data produced by computer-aided visual interpretation method on satellite images according to the "Land Cover/Use Classification" determined by the European Environment Agency. The main objective of the CORINE Project is to establish a standardized database for the purposes of determining environmental changes in the land, rational management of natural resources and formulation of environmental policies in line with the criteria and classification system determined by the European Environment Agency (URL-1, 2024).

Within the scope of the study, the data produced by the Turkish Ministry of Agriculture and Forestry for natural structure within the scope of the CORINE project according to the European Environment Agency criteria and classification units were utilized. In order to examine changes in land cover and land use, a total of 11 data under 4 main headings (excluding artificial regions) collected under the CORINE project were used. The change in the land cover of the Eastern Black Sea Region due to natural environmental factors was comparatively analyzed and evaluated by utilizing the data set of 2000 and 2018 produced at the district level. In addition to natural environmental factors, "population size" and "urban population ratio", which are effective in land cover change, are analyzed in the analysis of land cover change over time and space. Variables were also included in the process. The data on these 2 variables of socio-demographic structure were obtained from TUIK (Tab.2).

Indicators	Variables
2. Agricultural Areas (CORİNE)	Arable Areas (21)
	Continuous Products (22)
	Pastures (23)
	Mixed Agricultural Lands (24)
3. Forests and Semi-Natural Areas (CORİNE)	Forests (31)
	Maquis or Herbaceous Plants (32)
	Areas with Low or No Vegetation (33)
4. Wetlands (CORİNE)	Inland Wetlands (41)
	Coastal Wetlands (42)
5. Water Bodies (CORİNE)	Terrestrial Waters (51)
	Sea Waters (52)
Socio-demographic indicators (TUIK)	Population size
	Urban population size

Tab.2 Selected and grouped natural environment variables (URL-1, 2024)

2.3 Methodology

The study, which aims at rational use of natural resources and sustainable development, examines the change in land cover over the years. The district level study aims to reveal the similarities of the region according to the natural structure elements and to classify the districts according to the natural structure elements. Land cover variables of the natural structure of the Eastern Black Sea districts were classified with the help of cluster analysis. After the classification according to 2000 and 2018 natural structure elements, the clusters and the settlements in the clusters were compared and evaluated.

The change of the spatial pattern of the settlements of the Eastern Black Sea Region depending on the determined natural environmental variables was carried out with the help of cluster analysis. Cluster analysis is a method used in the process of organizing and analyzing multivariate or large scientific data. It aims to divide data that may have a high degree of similarity into several clusters in the same group/classification (Everitt, 1993; Shih et al., 2010). The similarity level of each cluster is defined by the distance between it and the system that each axis represents, and communities that are close to each other are more likely to be grouped in the same cluster (Vıncze & Mezei, 2011).

In the study, which aims to examine the change of land pattern at the district level over the years in order to manage natural resources rationally and create environmental policies, the "Two-Step Cluster" method from cluster analysis was used to reveal similar settlement texture and its change over the years. Two Step Cluster Method; It is a hybrid clustering technique formed by combining "K Means", a non-hierarchical clustering technique, and "Ward's Smallest Variance", a hierarchical technique (Ceylan et al., 2017). It is a single-pass data approach that allows using quantitative and qualitative variables simultaneously, determining preliminary clusters in the first step and then performing hierarchical clustering (Wu et al., 2016; Michailidou et al., 2009). In the pre-clustering stage of the method, the data are scanned one by one and it is decided whether the current situation will be combined with previously created clusters or whether a new cluster will be started according to the distance criterion (Michailidou et al., 2009). In the cluster step; data are grouped into the desired number of clusters using the standard hierarchical clustering algorithm according to the subsets obtained from the preliminary cluster step (Satish & Bharadhwaj, 2010).The most important features of this algorithm are; it can be applied to large data sets, can process categorical and continuous variables, can automatically determine the most appropriate number of clusters, and can remove observations that do not comply with the obtained clusters from the data when desired (Ceylan et al., 2017).

In this process, in order to reach valid and meaningful results in the analysis, the priority step is to select important variables and determine the number of clusters correctly (Punj & Stevvart, 1983). One of the most basic criteria developed to determine the number of clusters is that the number of clusters can be calculated with the expression k = (N/2)1/2 to indicate the number of N observations (Tatlıdil, 1992; Çakmak et al., 2005).

3. Result

In order to compare the time-dependent changes in the natural environmental elements of the Eastern Black Sea Region, a "two-step cluster analysis" was utilized. Population size and urban population variables affecting the change of land cover related to natural structure were also included in the clustering analysis process. Within the scope of the study, two-step clustering analysis was performed with 2 standardized variables of social structure and 9 standardized variables of natural structure. The analysis of 2000 and 2018 variables was carried out with the help of SPSS 25.0 package program. "Wetlands" that are not located in the Eastern Black Sea Region were excluded from the data set (Tab.3-4-5-6). As a result of the analyzes, the spatial distribution of the time-dependent changes of the natural environmental elements of the Eastern Black Sea Region at the district level were mapped and interpreted (Fig.3-4).

3.1 Spatial reflections of natural structure land cover: year 2000

First of all, Two-Step Cluster Analysis was performed with 11 variables belonging to 6 provinces and 79 districts in the Eastern Black Sea Region. In the study, it was aimed to determine a common number of clusters in order to make comparisons between the clusters to be formed with the help of variables from different years (2000 and 2018). The optimum cluster number formula (cluster number k = (N/2)1/2) was used to determine the number of clusters. It was decided that the number of clusters to be used in the clustering analysis and to reflect the diversity of 79 districts - indicated by the cluster number formula - should be "6".

Variable (importance)	**Cluster-1**	**Cluster-2**	**Cluster-3**	**Cluster-4**	**Cluster-5**	**Cluster-6**
	%36.71	**%7.59**	**%29.11**	**%12.66**	**%6.33**	**%7.59**
	29 districts	6 districts	23 districts	10 districts	5 districts	6 districts
31. Forests (1)	-0.58	-0.33	-0.24	1.25	-0.37	2.27
21. Arable areas (0.99)	-0.23	-0.22	-0.23	-0.2	3.31	-0.21
Population size (0.82)	-0.44	3.06	0.05	-0.2	-0.23	-0.07
32. Maquis or Herbaceous Plants (0.75)	-0.51	-0.48	-0.43	1.11	1	1.87
24. Mixed agricultural lands (0.57)	-0.85	1.58	0.08	0.58	0.76	0.55
Urban population size (0.51)	-0.35	2.68	0.08	-0.26	-0.07	-0.37
23. Pastures (0.5)	-0.24	-0.24	-0.23	-0.16	2.74	0.25
33. Areas with Little or No Vegetation (0.44)	-0.38	-0.39	-0.35	0.36	1.49	1.74
52. Sea waters (0.38)	-0.42	1.63	0.67	-0.51	-0.55	-0.55
51. Terrestrial waters (0.18)	-0.44	0.26	0.33	-0.38	-0.32	1.36
22. Continuous products (0.09)	-0.13	1.15	-0.18	-0.2	-0.21	0.92
Ranking of mean values	Lowes					Highest

Tab.3 Importance level-mean values of variables effective in the formation of clusters (2000)

Variable (2000)	**Cluster-1**	**Cluster-2**	**Cluster-3**	**Cluster-4**	**Cluster-5**	**Cluster-6**
	36.71%	**7.59%**	**29.11%**	**12.66%**	**6.33%**	**7.59%**
	29 districts	6 districts	23 districts	10 districts	5 districts	6 districts
Artvin	(1) Murgul		(2) Arhavi, Hopa	(1) Ardunuç,		(4), Şavşat, Yusufeli, Merkez, Borçka
Giresun	(6) Doğankent, Eynesil, Güce, Piraziz, Yağlıdere, Çanakçı	(1) Merkez	(4) Espiye, Görele, Keşap, Tirebolu	(3) Alucra, Bulancak, Dereli	(2) Çamoluk, Şebinkarahisar	
Gümüşhane				(1) Torul	(3) Kelkit, Köse, Şiran	(2) Merkez, Kürtün
Ordu	(9) Aybastı, Gülyalı, Gürgentepe, Kabadüz, Kabataş, Çamaş, Çatalpınar, Çaybaşı, İkizce	(2) Altınordu, Fatsa, Ünye	(5) Gölköy, Korgan, Kumru, Perşembe, Ulubey	(2) Akkuş, Mesudiye		
Rize	(5) Derepazarı, Güneysu, Hemşin, Kalkandere, İyidere		(5) Ardeşen, Fındıklı, Pazar, Merkez, Çayeli	(2) Çamlıhemşin, İkizdere		
Trabzon	(8) Beşikdüzü, Çarşıbaşı, Dernekpazarı, Düzköy, Hayrat, Köprübaşı, Şalpazarı, Tonya	(2) Akçaabat, Ortahisar,	(7) Araklı, Arsin, Çaykara, Of, Sürmene, Vakfıkebir, Yomra	(1) Maçka		

Tab.4 Distribution of districts according to clusters as a result of the analysis (2000)

After determining the number of clusters as 6, natural structure clusters for the year 2000 were formed as a result of the Two-Step Clustering analysis. As a result of the analysis, it was seen that the most effective variables in the formation of similarities between the districts in 2000 were "forests" and "arable areas". The least effective variable in the analysis where natural environment components are the most effective is "continuous products" (Tab.3).

In 2000, the distribution of the variable values formed as a result of the Two-Step Clustering analysis with the variables belonging to the year 2000 to the clusters was analyzed. Cluster characteristics were determined by comparing the "Mean" values of all variables between clusters. As a result of the holistic and comparative evaluation of 11 variables and 6 clusters, the clusters were grouped according to their natural environment characteristics. As a result of the two-step clustering analysis, there are 29 districts in the Eastern Black Sea Region that show the highest number (36.7%) of Cluster-1 characteristics in 2000 (Tab.3-4) (Fig.3).

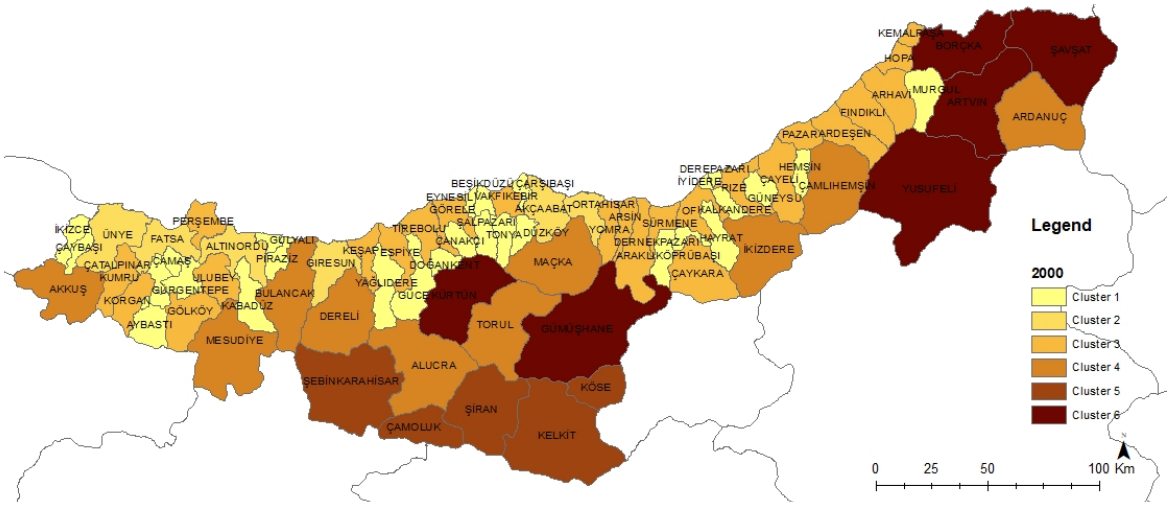

Fig.3 Spatial distribution of settlements according to natural structure components (2000)

The clusters and cluster characteristics formed as a result of the classification according to natural environment elements and socio-demographic components are as follows.

- Cluster-6 has the highest values of the variable "forest and semi-natural areas (3)", which is one of the natural environment components. And Cluster-6 consists of 6 districts of Artvin and Gümüşhane provinces. Settlements belonging to the cluster have the highest values in terms of "forests (31)", "maquis or herbaceous plants (32)", "areas with little or no vegetation cover (33)";
- Another natural environment component is "agricultural areas (2)". Cluster-5 settlements have the highest values in terms of "arable areas (21)" and "pastures (23)" within the agricultural areas indicator set. It is seen that all 5 districts of Giresun and Gümüşhane provinces are rich in natural areas;
- Following Cluster 6 and Cluster 5, Cluster-4 settlements have the highest values for "forests (31)", "frable lands (21)" and "maquis or herbaceous plants (32)";
- Cluster-2, where "population size" and "urban population size" have the highest values, consists of Akçaabat, Ortahisar, Ünye, Fatsa and Giresun central districts. This cluster shows similar characteristics in terms of population and natural structure components;
- Cluster-3 settlements have the highest "population size" and "size of urban population" values after Cluster-2 settlements. In addition, these cluster districts are also important in terms of "water bodies (5)" and "forests (31)" and show similar characteristics. This cluster, consisting of 23 districts in total, covers 29% of the region.

As a result, cluster analyse shows that in the 2000s, the natural structure - forests - was important in the classification of settlements according to their similarities and differences. It is also observed that 29 districts

with the lowest values in terms of both population and natural structure elements are included in Cluster-1, showing similar characteristics.

3.2 Spatial reflections of natural structure land cover: year 2018

Following the 2000 clustering analysis, clustering analyses were conducted with the natural structure and population variables in 2018. According to 2000 and 2018 natural structure components, the distribution of settlements into clusters was compared. The spatial reflections of the changing land cover over the past 20 years were analyzed. As a result of the two-step clustering analysis with population and natural structure variables, approximately half (53.16%) of the settlements in the Eastern Black Sea Region were located in Cluster-1. In 2018, it was observed that the most effective variables in the formation of similarities between districts were "population size" and "urban population size". In the analysis where natural environment components are the most effective, the least effective variable is "arable land" (Tab.5-6).

Variable (importance)	**Cluster-1**	**Cluster-2**	**Cluster-3**	**Cluster-4**	**Cluster-5**	**Cluster-6**
	53.16%	**8.86%**	**7.59%**	**20.25%**	**3.79%**	**6.32%**
	42 districts	7 districts	6 districts	16 districts	3 districts	5 districts
Population size (1)	-0.33	2.77	-0.02	-0.27	-0.5	0.05
Urban population size (0.92)	-0.28	2.74	-0.1	-0.3	-0.41	-0.18
32. Maquis or Herbaceous Plants (0.87)	-0.48	-0.54	-0.44	0.85	0.87	2.53
33. Areas with Low or No Vegetation (0.79)	-0.3	-0.35	-0.35	0.11	-0.13	3.11
22. Continuous Products (0.65)	-0.18	1.81	1.59	-0.48	-0.74	-0.91
23. Pastures (0.63)	-0.26	-0.13	-0.29	0.13	3.85	0
52. Sea Waters (0.46)	-0.23	1.35	1.84	-0.433	-0.49	-0.49
31. Forests (0.45)	-0.41	-0.46	-0.58	1.1	-0.22	1.39
51. Terrestrial Waters (0.35)	-0.29	0.12	-0.14	0.07	-0.36	2.44
24. Mixed Agricultural Lands (0.2)	-0.38	0.59	-0.59	0.7	-0.29	1.02
21. Arable Areas (0.13)	-0.18	-0.19	-0.19	-0.07	1.18	1.52
Ranking of mean values	Lowest					Highest

Tab.5 Importance level-mean values of variables effective in the formation of clusters (2018)

Variable (2018)	**Cluster-1**	**Cluster-2**	**Cluster-3**	**Cluster-4**	**Cluster-5**	**Cluster-6**
	53.16%	**8.86%**	**7.59%**	**20.25%**	**3.79%**	**6.32%**
	42 districts	7 districts	6 districts	16 districts	3 districts	5 districts
Artvin	(3) Arhavi, Hopa, Murgul			(3) Ardunuç, Borçka, Şavşat		(2) Merkez, Yusufeli
Giresun	(8) Doğankent, Espiye, Eynesil, Güce, Piraziz, Yağlıdere, Çamoluk, Çanakçı	(1) Merkez	(3) Görele, Keşap, Tirebolu	(3) Alucra, Bulancak, Dereli,		(1) Şebinkarahisar
Gümüşhane				(3) Kürtün, Torul, Şiran	(1) Köse	(2) Merkez, Kelkit
Ordu	(11) Gölköy, Gülyalı, Gürgentepe, Kabadüz, Kabataş, Korgan, Kumru, Çamaş, Çatalpınar, Çaybaşı, İkizce	(3) Altınordu, Fatsa, Ünye	(1) Perşembe	(4) Akkuş, Aybastı, Mesudiye Ulubey,		
Rize	(8) Ardeşen, Derepazarı, Fındıklı, Güneysu, Hemşin, Kalkandere, Çayeli, İyidere,	(1) Merkez	(1) Pazar	(2) Çamlıhemşin, İkizdere		
Trabzon	(12) Arsin, Beşikdüzü, Çarşıbaşı, Dernekpazarı, Düzköy, Hayrat, Of, Sürmene, Şalpazarı, Tonya, Vakfıkebir, Yomra	(2) Akçaabat, Ortahisar,	(1) Araklı	(1) Maçka	(2) Çaykara, Köprübaşı	

Note. Underlined settlements indicate the districts that were in the same cluster in the previous period

Tab.6 Distribution of districts according to clusters as a result of the analysis (2018)

According to the evaluation made by comparing with the 2000 data, the following results were obtained (Tab.5-6), (Fig.4):

- Cluster-6, which has the highest values of "forest and semi-natural areas (3)" among the natural environment components, consists of 5 districts of Artvin, Gümüşhane and Giresun provinces. Settlements belonging to the cluster have the highest values in terms of "forests (31)", "maquis or herbaceous plants (32)", "areas with little or no vegetation cover (33)" in this period. In 2000, Artvin Merkez, Yusufeli and Gümüşhane Merkez districts were in the same cluster in this period;
- As a result of the 2018 cluster analysis, it is seen that a new cluster with different characteristics from the previous period was formed. Cluster-5 has the highest values for the variable "pastures" and the highest values for the variable "maquis or herbaceous plants (32)". Cluster 5 consists of Çaykara and Köprübaşı districts of Trabzon province and Köse district of Gümüşhane province. In addition, the population values of this cluster are lower than the other clusters;
- It is seen that the variables "pasture areas", "forest" and "areas with little or no vegetation cover", which are agricultural area variables of the natural environment, have high values for Cluster-4 after Cluster-6. In addition, the cluster has secondary importance in terms of "mixed agricultural areas" as in the previous period. Cluster-4, which consists of different cluster settlements in 2000, is completely heterogeneous. Cluster-4 consists of 16 districts and covers 20.25% of the total settlements;
- Cluster-3, which has the highest values in terms of "sea waters", the highest values in terms of "continuous product" and "urban population size" variables and the lowest values in terms of many other variables, consists of a total of 6 districts in 2018. In the last 20 years, the number of settlements in Cluster-3 with similar characteristics has decreased. Settlements belonging to the cluster consist entirely of settlements that were in Cluster-3 in the previous period;
- Cluster-2, where "population size" and "urban population size" have the highest values, consists of Akçaabat, Ortahisar, Ünye, Fatsa and Giresun central districts as in the previous period. In addition, Altınordu and Rize Central districts also show similar characteristics (Cluster-2) in terms of population and natural structure components;
- Finally, it is observed that a heterogeneous group consisting of settlements that were in Cluster-1 and Cluster-3 in the previous period has emerged. This cluster has moderate values in terms of both population and natural structure components. This cluster consists of 42 districts and covers 53.16% of the settlements in the region.

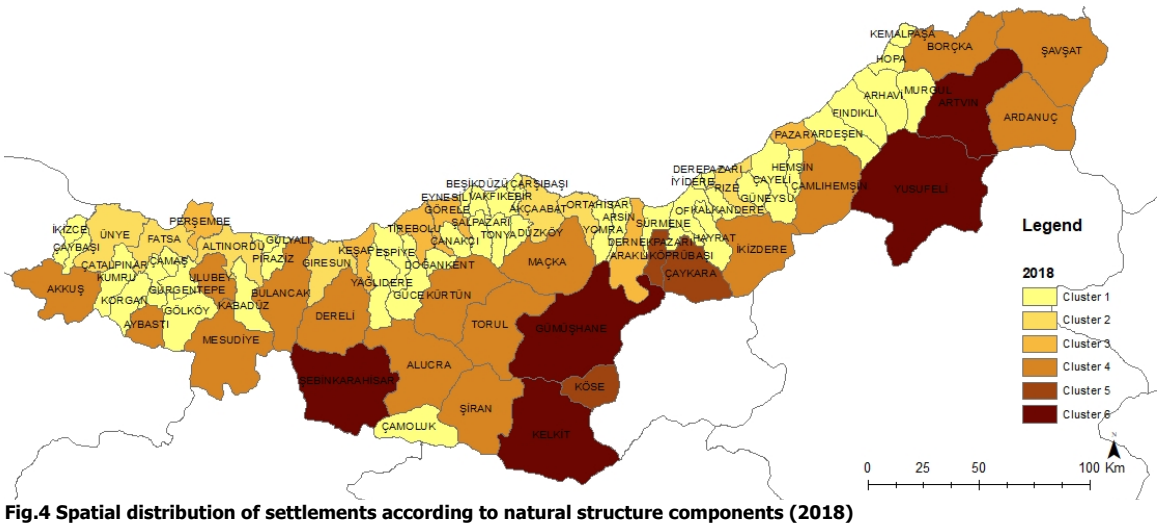

Fig.4 Spatial distribution of settlements according to natural structure components (2018)

4. Discussion

Urbanization has a significant impact on social, economic and environmental sustainability. Dynamic urban development and change processes that have occurred recently as a result of increasing urban population movements affect both the natural and built environment. Within the scope of the study, the changes of 6 provinces and 79 districts within the Eastern Black Sea region, which are considered rich in natural environmental elements, were examined depending on "agricultural areas", "forest and semi-natural areas", "water bodies" and "population size".

In 2000, the most influential variable in cluster formation was "forests". The repeated analysis at the end of approximately 20 years shows the impact of urbanization on space. Namely, the most effective variables of the clusters formed in 2018 were "population" and "urban population". It was observed that the similarities and differences of the settlements were determined by social structure dynamics, unlike the natural structure elements that were effective in the previous period.

According to the time-based comparative evaluation for the Eastern Black Sea Region, Cluster-1 and Cluster-2 have the lowest values in terms of natural structure elements, while Cluster-6 has the highest values. In 2018, it is observed that the spatial continuity of Cluster-6 settlements - natural structure continuity - has deteriorated especially in Artvin province. It is seen that Borçka and Şavşat districts, which are rich in natural environmental elements, have similar characteristics with Ardanuç district in 2018.

In 2018, the number of settlements in Cluster-4, which has high values in terms of "forest", "arable land" and "pastures", increased compared to the previous period. Especially in the south of Trabzon and Giresun provinces, there is a change and spatial continuity due to natural structure elements. In 2000, some of the Cluster 5 and Cluster 6 settlements with high natural structure elements were included in Cluster-4 in this period.

The number of Cluster-1 settlements, where "population" and "urban population size" and natural structure components have medium-low values, has increased over time. This change in the coastal and especially in the eastern part of the region is significant and remarkable. While 36.71% of the settlements in the region were in Cluster-1 in 2000, this rate increased to 53.16% in 2018.

Finally, in both periods, it is observed that the districts of Artvin and Gümüşhane provinces are concentrated in clusters rich in natural structure elements. Rize and Trabzon provinces, on the other hand, show a trend in the opposite direction. This situation is consistent with the observed changes in the region. The results of clustering analyses based on the similarities and differences of natural environment components and social structure elements show that the settlements within the provinces have a heterogeneous distribution and that there are differences between coastal and inland areas (Tab.4).

5. Conclusion

The transformation of natural areas is a vital issue for ecosystems. Over time, the protection of nature for future generations becomes even more important. In this respect, the study aims to analyze the land cover changes in the natural structures of the settlements in the Eastern Black Sea Region over time and to classify the settlements according to their natural structure similarities. The study shows that "artificial areas" and "agricultural areas" increased and "forest areas" decreased in the region from 2000 to 2018. In addition, the spatial patterns of land cover changes were also revealed with the classification studies conducted specifically for settlements. Clusters formed according to similarities in natural structure also enabled the identification of transitions between each land use. Time-dependent classification and mapping of land cover changes can serve as a valuable tool to protect environmentally sensitive areas from further damage. Another issue is that land cover changes are associated with physical and socioeconomic impacts. However, the availability of current and up-to-date physical and socioeconomic data is limited. This is a limitation of this study, which was designed to monitor spatial and temporal land cover change and reveal complex human-nature interactions.

It is recommended that future studies be conducted in a holistic manner with rich and up-to-date data sets. The results will provide important insights for planners and key actions to ensure sustainable development in the region and reduce degradation of the natural environment. This information will help in the formulation of land planning strategies and the development of land use conservation policies. Such studies will contribute to the planning discipline in terms of addressing economic and ecological decisions together, the necessity of rational resource utilization and making environmentally sensitive land use decisions.

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Image Sources

All figures are original produced by the authors for this paper.

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