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ASSESSMENT OF TEMPORAL COASTLINE DYNAMICS AND LAND TRANSFORMATION USING CORINE, GIS AND REMOTE SENSING

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ABSTRACT

Coastal areas where the majority of the society live are exposed to geographical changes. Observing the changing coastline and usage areas is important in terms of efficient use of the areas and directing the future. Remote Sensing (RS) is used effectively in change detection analyses and spatial studies in the recent years. This paper focuses mainly on the coastal line changes of Trabzon, Turkey by using Geographic Information Systems (GIS) and Remote Sensing (RS) by examining the Landsat and Google earth images. Landsat images were obtained for 2002, 2009, 2015, 2021 and Google earth data were provided for 2002, 2012, 2021 years. The land use type of the changing areas were examined using the 2000 and 2018 Corine data. According to the results of the study, it was observed that there was a remarkable growth in the coastal areas towards the sea. It has been concluded that this growth is mostly formed by the filling areas built into the sea. After the evaluation with Corine data, it has been determined that the areas that have changed have turned into sports, recreation, highway and port areas in 20 year period.

Keywords: Land Use, GIS, Corine, Change Analysis, Google Earth, Landsat, Remote Sensing.

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INTRODUCTION

For centuries, coastal areas have been one of the most preferred places for communities to settle. The fact that coastal areas are so important for communities has continued until today with factors such as trade, tourism, raw material source (sand, salt, mining areas), defence (sea bases, military areas), transportation, irrigation, energy, food and socio-cultural factors. Coastline is “the line formed by the junction of the points where water touches the land in seas, lakes and rivers, except in cases of flood”; The coastal edge line is defined as "the natural border of sandy, gravelly, rocky, stony, reedy, swamp and similar areas in seas, lakes and rivers where water movements occur in the land direction after the shore line" (Coastal Law No. 3621).

Changes in coastal areas include deterioration in the coastline that occur naturally or by human means. Coastal changes are called coastal advance or coastal regression. Coastal recession can occur due to factors such as melting of sand, coastal erosion, waves and sea currents. On the other hand, coastal progress can be formed by filling materials carried by water (Bird, 2008). The physical change of coastal areas affects many lives. In terms of ecological life, the routes of migrating birds are changing, and the habitats of many plants are affected. This situation disrupts the balance of nature and affects environmental pollution (Martínez et al., 2007). Turkey is surrounded by seas on three sides, has a total coastline of 8,333 km, and is a country where the concept of coast is of great importance. Coastal areas are globally recognized as focal points of human and economic activities, and this pattern is also observed in Türkiye (Akkaya, 2004; Kocadağlı, 2022).

Satellite remote sensing (RS) has revolutionized the observation of the Earth by enabling more accurate information to be obtained through the systematic evaluation of land surfaces (Yilmaz, 2004; Yongxue et al., 2019). There is an increase in the use of satellite images in the discipline of cartography due to the fact that satellite images provide continuous information, ease of updating, update speed, absence of legal obstacles in taking and evaluating images, and especially increasing geometric accuracy with high resolution satellite images (Mutluoğlu & Yakar, 2005; Müller et al., 2012; Mutluoglu et al., 2015; (Mutluoglu et al., 2016). Medium-resolution RS images have been widely used in various studies including, agriculture, landuse /cover mapping, change detection, object determination, urban expansion, deforestation, land degradation, shoreline change (Lu et al., 2007; Wu, 2007; Duveiller et al., 2008; Seto and Fragkias, 2005; Yu et al., 2011).

While Geographic Information System (GIS) is a system that performs location-based data acquisition, analysis, storage and presentation on the earth's surface for a specific purpose, RS technology is a technology for creating a data base. In recent years, RS and GIS technologies have been used effectively in coastline changes and spatial observations. Variation analysis provides a method for comparing images of an object taken at different times or under different conditions. There are many studies in this field in the national and international literature (Korkut et al., 2008; Doğan, 2008; Erener &

Düzgün, 2009; Kirui et al,. 2011; Chen et al., 2012; Olgun, 2012; Sekovski et al., 2012; Hussain et al., 2013; Kaya, & Toroğlu, 2015; Ma et al., 2016; Mishra et al., 2017; Nassar et al., 2018; Akdeniz, 2021; Erener & Yakar, 2012; Erener & Yakar, 2015; Uzan & Özcan, 2016; Sarı &Yüksel, 2020).

In the Akdeniz (2021) study, orthophoto maps of the years 1957, 1964, 1972, 1993, 2009, 2018, 2020 were used to examine the short- and long-term changes on the shores of the Küçük Menderes Delta. It was determined that there was an accumulation of up to 37.01 ha in the Küçük Menderes Delta between 1957 and 2020 and the length of the coastline decreased by 172.17 m. Nassar et al. (2018) examined the 27-year coastline change along the North Sinai coast of Egypt. Satellite data acquired at different times from the Landsat Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) were processed in ArcGIS using scripts developed in the Python programming language. Kirui et al. (2011), the coastline change of Mangrove Forest land, which is very important to the people of Kenya, was analysed using red, near-infrared and middle-infrared bands of Landsat Thematic Mapper (TM) satellite images and aerial photographs and SRTM data for the years 1985, 1992, 2000 and 2010. In this study, it is aimed to monitor and analyse the change of the Trabzon coastline between 2002-2021. Google Earth and Landsat 5 and Landsat 8 satellite images with different resolutions were used for analysis. With the help of GIS-based analyses, areas of spatial change in the coastline have been determined over a 20-year period. The usage purposes of the landfills in coastal areas were examined with the help of Coordination of Information on the Environment (Corine) 2006 and 2018 data. With the help of the data obtained, the land use type of the areas that make up the change in the coastline has been revealed.

1. MATERIALS AND METHOD

1.1 Study area and data

The study area is the province of Trabzon, located in the northeast of Turkey. In the province, which has a coast to the Black Sea, they form small plains where the rivers reach the sea (Pural, 1995). These plains are places where crowded settlements are seen, although their lands are fertile (URL-1).

Due to the mountainous nature of the province, the settlements are scattered in the villages, on the other hand they are very close to each other at the coastal region. This both caused the formation of unplanned urbanization and led to studies to enlarge the city centre area by filling the sea. The study area is shown in Figure 1.

Figure 1. Study area.

In this study, 30 m resolution reflective bands Landsat 5 images of 2002 and 2009 and 30 m resolution reflective bands Landsat 8 images of 2015 and 2021 were used. Landsat images are downloaded free of charge from Earth explorer platform (https://earthexplorer.usgs.gov). Google Earth is a web-based computer program that displays photos of different resolutions obtained at different times from various satellites on Earth. Google Earth, which was initially released on June 11, 2001, has enabled detailed viewing of most cities worldwide since June 2006. In this study, using Landsat data as well as google earth data, analyses were applied from two different systems and compared. In this context, Google Earth images of the area for the years 2002, 2012, 2021 were downloaded and used. In addition, 100 m resolution Corine data for the years 2000 and 2018 were used to obtain land information. The Corine Project, which started in Portugal in 1985, is a system that includes the land cover and land use of all European countries (Tekin, 2019). The aim is to create a common database in the system where information is collected and shared over the cartographic map according to priority issues such as water, vegetation and land cover determined by the European Environment Agency (ACA). Turkey joined the project in 1998. Initial studies were completed in 2008 using 2000 Landsat satellite images.

A common classification language is used to express the areas that make up the land within the scope of the project. Classifications were made according to land use patterns. The classification, which consists of five basic classes, has 44 subclasses. Corine data was downloaded from the Corine Project website (https://land.copernicus.eu/). Also in the study, Turkey's Civil Boundaries Map was down-

loaded free of charge from the General Command of Mapping's website (https://www.hgk.msb.gov.tr/) and used as a base for the district borders map. The data used are shown in Table 1.

Table 1. Data Used.

Data Name	Year	Format	Resolution (m)
Landsat			
Landsat 5MS	2002 2009	Raster Raster	30(MS bands) 30(MS bands)
Landsat 8	2015 2021	Raster Raster	30(MS bands) 30(MS bands)
Google Earth			
Landsat/Copernicus Maxar Technologies	2002	Raster	30 0.3
Maxar Technologies	2012	Raster	0.3
Maxar Technologies CNES/Airbus	2021	Raster	0.3 0.5
Corine	2006 2018	Raster Raster	100 100
Türkiye administrative boundaries		Vector	

1.2 Method

The flow chart of the study is shown in Figure 2. In order to fit the images saved as images from the Google Earth Pro program to their real coordinates on the world, georeferencing has been included and the coordinate system has been defined. All satellite data, spatially overlapped with Landsat data, are masked for the Trabzon Değirmendere coastal region where the change occurred. Since the focus of the study is coastal change, two basic classes, sea and land, were created and samples were collected from the sea surface and the land surface. Supervised classification was applied with the samples. The classified raster data was converted into polygons and lines, and after editing, the changing areas of the coastline were determined using the polygon difference method. These processes were repeated for all satellite images. The obtained data and Corine data were masked with the district boundaries, then the Corine data were divided into categories and organized. Finally, the land use transformation was determined by overlapping the areas where the change occurred with the Corine data.

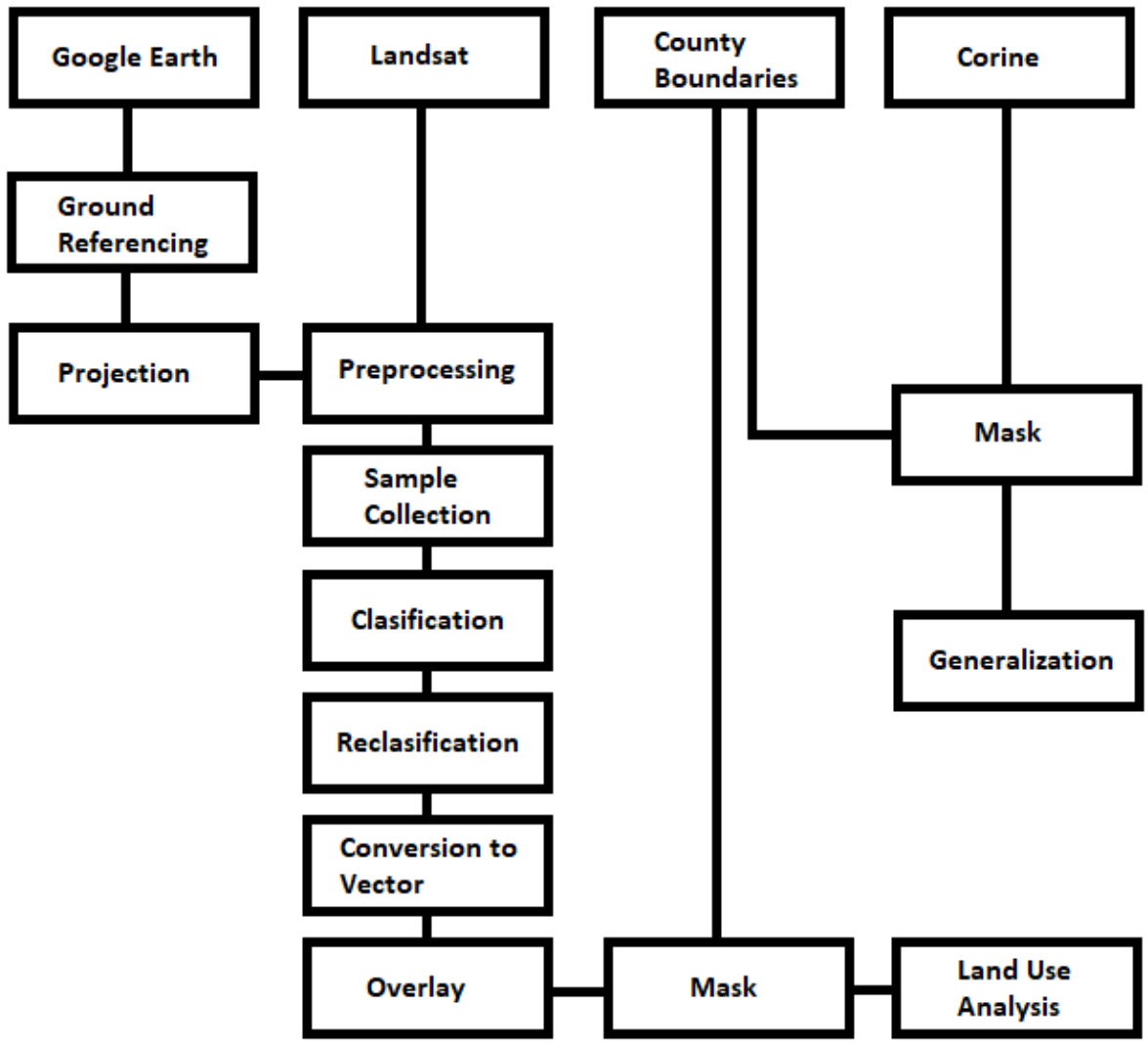

Figure 2. Process steps.

2. RESULTS

2.1 Landsat change analysis

The changing areas of the coastline were determined as a result of the supervised classification process by creating two basic classes, sea and land, with Landsat satellite images of 2002, 2009, 2015, 2021. Area calculations of images belonging to different years were obtained. It has been determined that the coastal area has grown by 142.18 hectares between 2002-2009, 61.34 hectares between 2009-2015, 56.76 hectares between 2015-2021. The area changes of the 260.30 ha growing area in total over the years are shown in Table 2.

Table 2. Landsat coastal change areas.

Year Range	Area Difference (ha)	Change Period (Annual)
2002 – 2009	142.18	7
2009 - 2015	61.34	6
2015 - 2021	56.76	6
2002 - 2021	260.30	19

By overlaying the images, the locations of the changed areas were determined. The changed areas are shown in Figure 3.

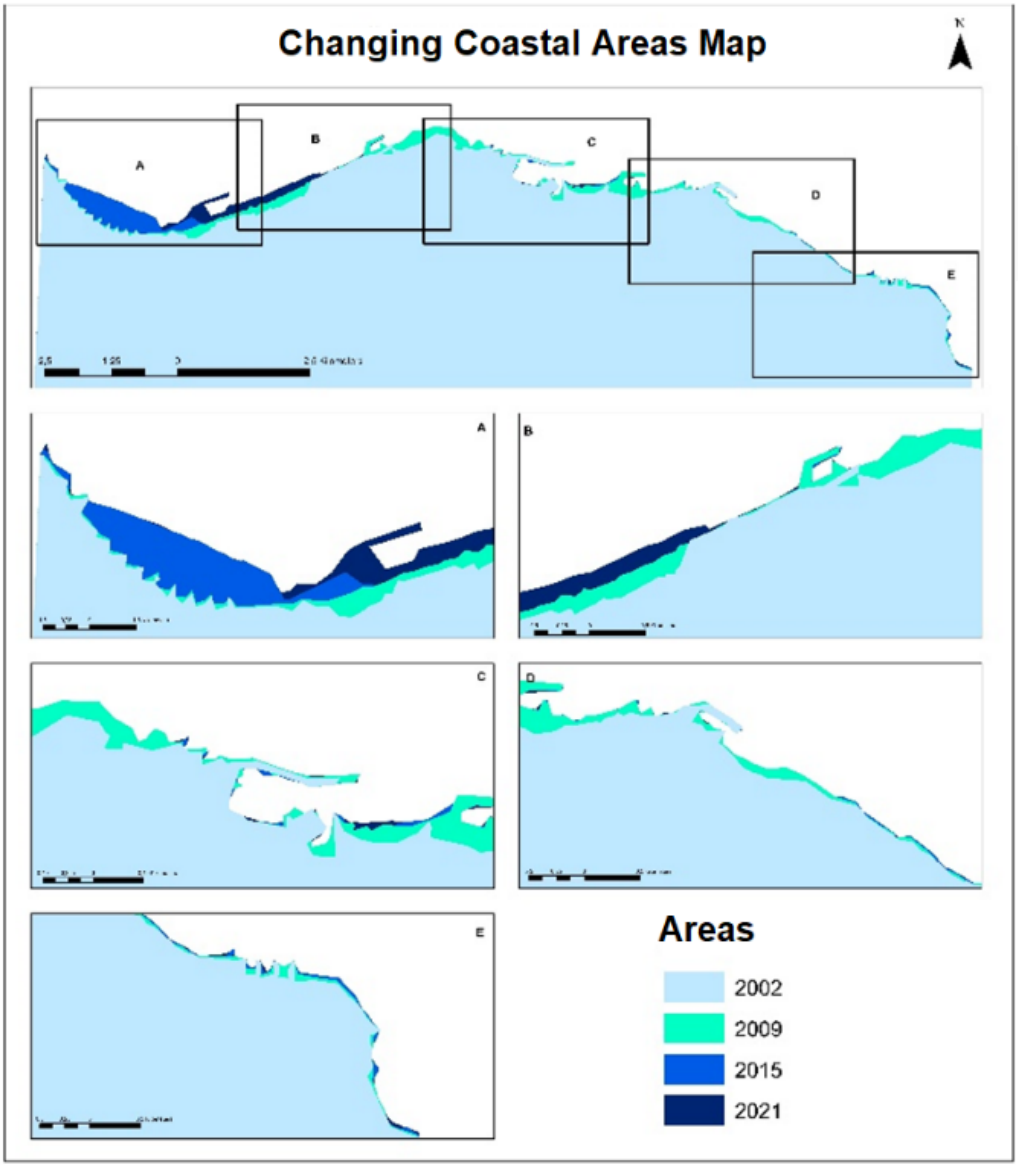

Figure 3. Coastline change map produced with Landsat images.

The change rates of Trabzon province, which underwent a coastal change of 260.30 hectares between 2002 and 2021, were converted into a pie chart and shown in Figure 4.

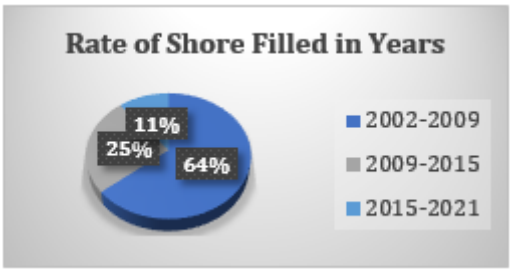

Figure 4. Ratio of fill areas of Trabzon coastline.

2.2 Google Earth change analysis

The changing areas of the coastline were determined as a result of the supervised classification process by creating two basic classes, sea and land, with Google Earth satellite images for the years 2002, 2012 and 2021. Area calculations of images belonging to different years were made. The area measurements derived from images acquired in different years were systematically evaluated. It has been determined that the coastal area has grown by 162.62 hectares between 2002-2021 and 72.44 hectares between 2012-2021. The area changes of the 235.06 hectares growing area in total over the years are shown in Table 3.

Table 3. Google Earth coastal change areas.

Year Period	Area Difference (ha)	Change Period (Annual)
2002 - 2012	162.62	10
2012 - 2021	72.44	9
2002 - 2021	235.06	19

By overlaying the images, the locations of the changed areas were determined. The changed areas are shown in Figure 5.

The change rates of Trabzon province, which underwent a coastal change of 235.06 hectares between 2002 and 2021, are shown in Figure 6, which has been converted into a pie chart. The percentage distribution indicates that 31% of the total coastline change occurred between 2002 and 2012, while the remaining 69% occurred between 2012 and 2021.

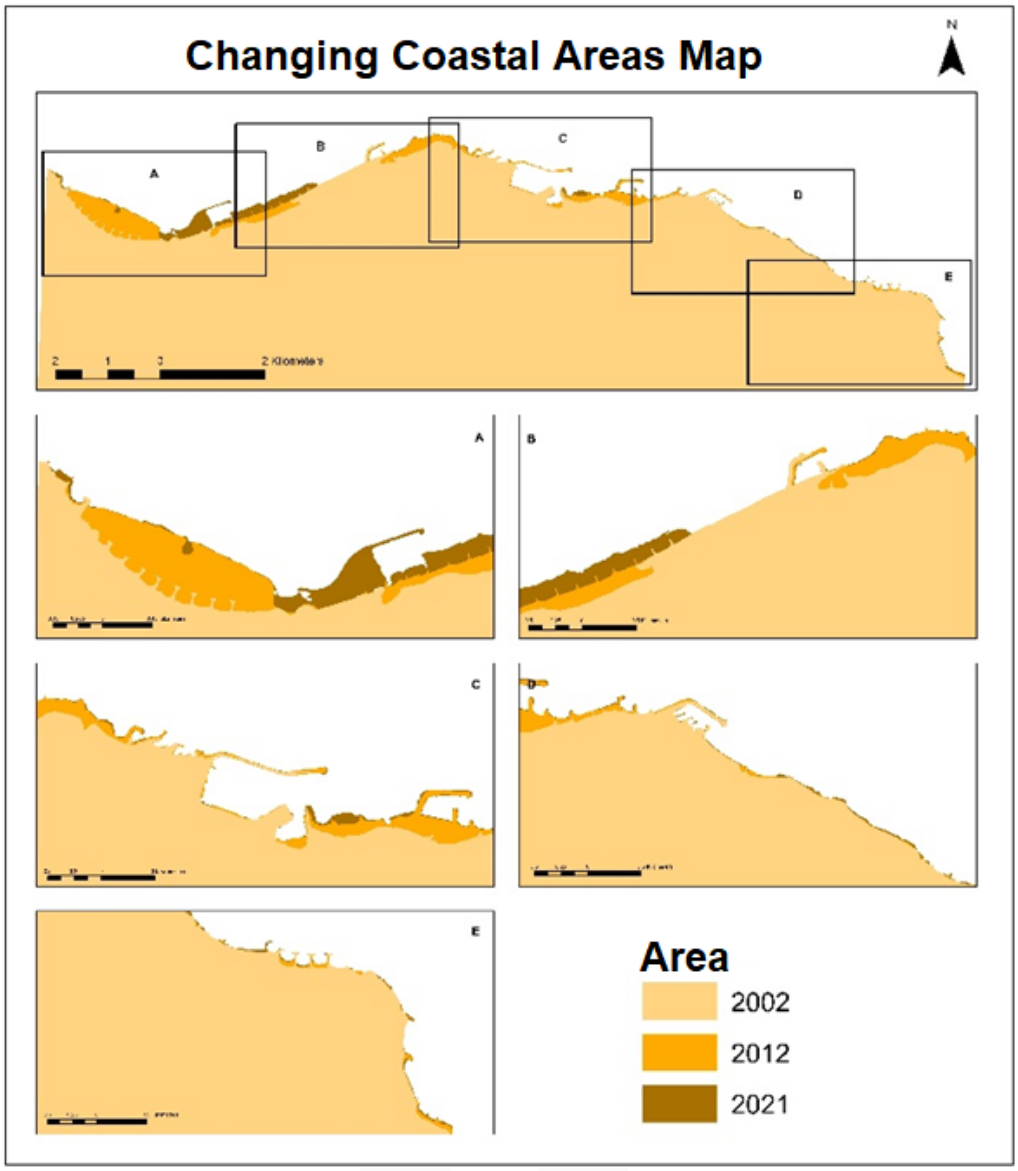

Figure 5. Coastline change map produced with Google Earth images.

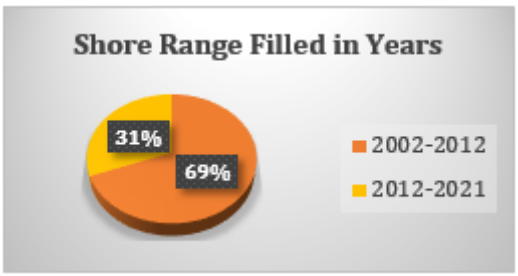

Figure 6. Ratio of fill areas of Trabzon coastline.

2.3 Comparison of Landsat and Google Earth Studies

In the studies conducted for the same region between 2002-2021, the spatial change of the Trabzon coastline was 260.30 hectares with Landsat satellite images, while it was 235.06 hectares with Google Earth satellite images. The reason why the two spatial changes are different is the spatial resolution differences of the Google Earth satellite images. The change of the coastline is overlaid with Landsat and Google Earth satellite images and shown in Figure 7.

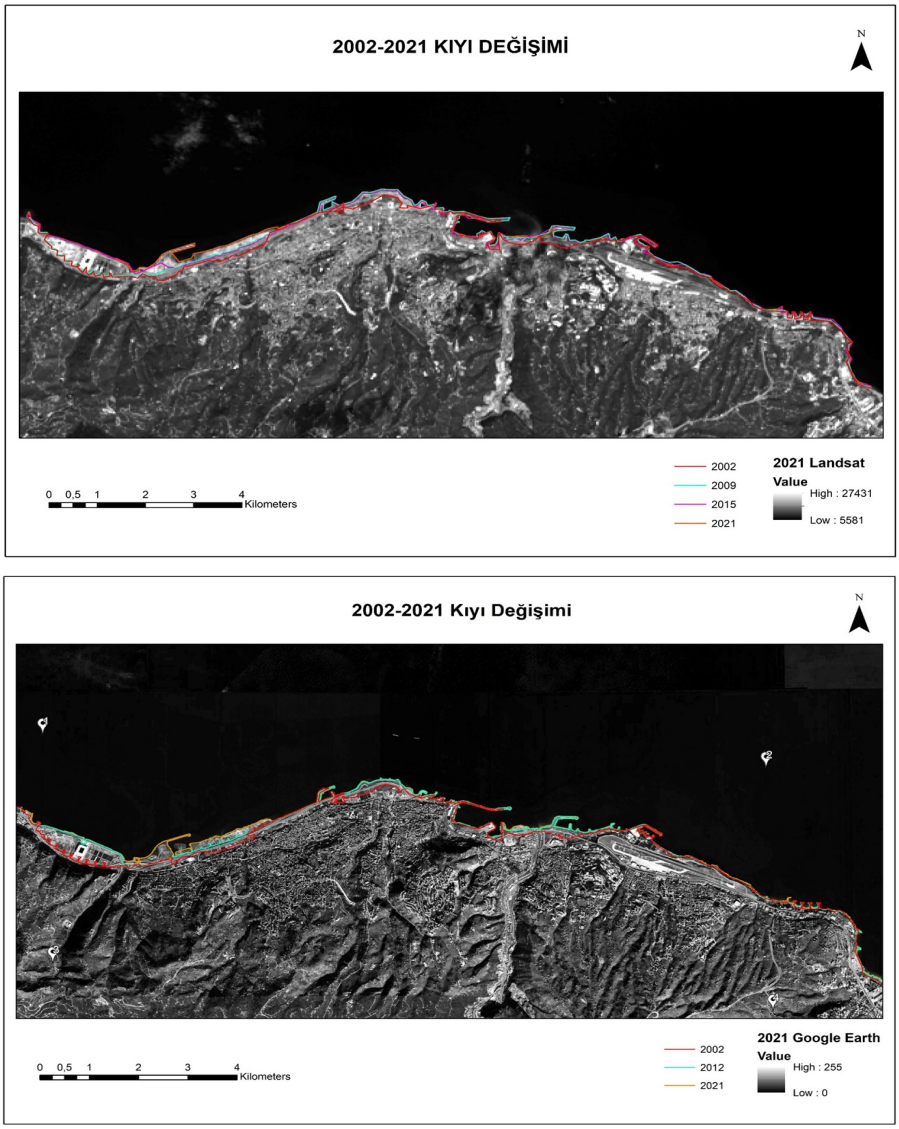

Figure 7. Demonstration of coastline change on Landsat satellite image and google earth images.

2.4 Corine land use maps

Once the coastline change analysis had been completed, the CORINE datasets were classified into their respective land cover categories and reorganized according to the official area codes. These categorized datasets were then spatially overlaid with the detected coastline change areas to identify the

corresponding land use types. The resulting land use maps for the years 2000 and 2018 are presented in Figure 8 and Figure 9.

The land use map of 2018 was overlaid with the coastal strip change data obtained with the Landsat images of 2002, and the land uses of the filled area were determined and shown in Figure 10.

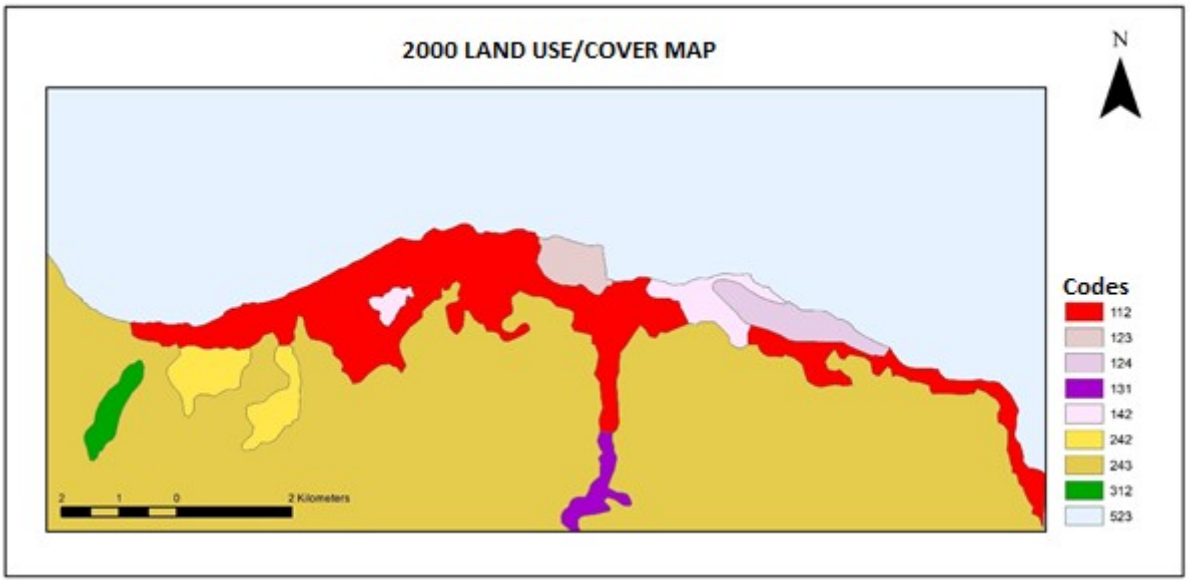

Figure 8. Trabzon coastline land use map in 2000.

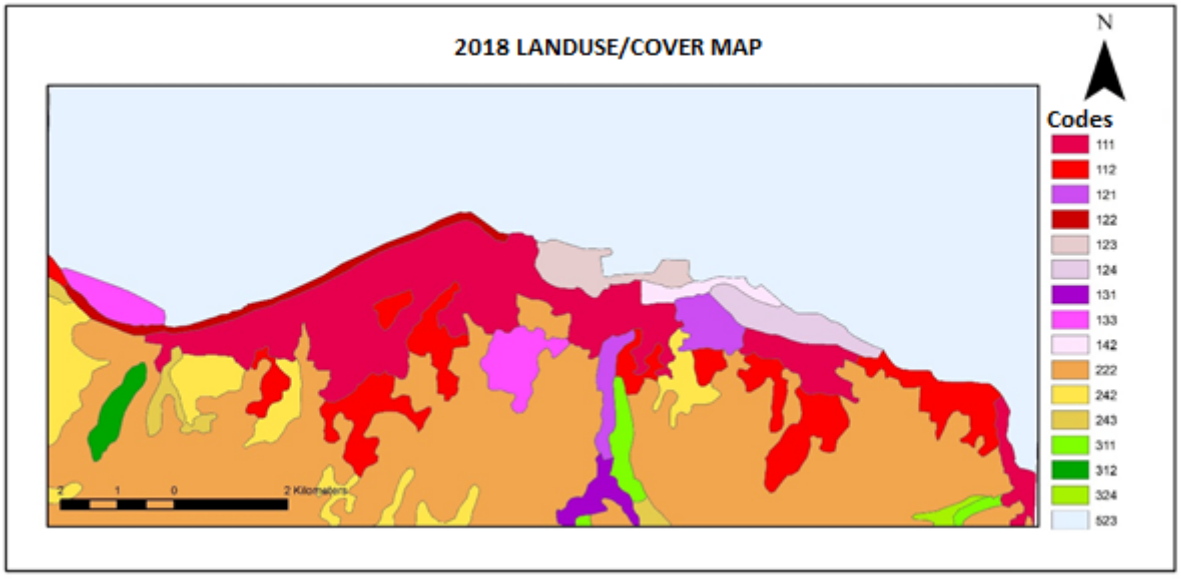

Figure 9. Trabzon coastline land use map for 2018.

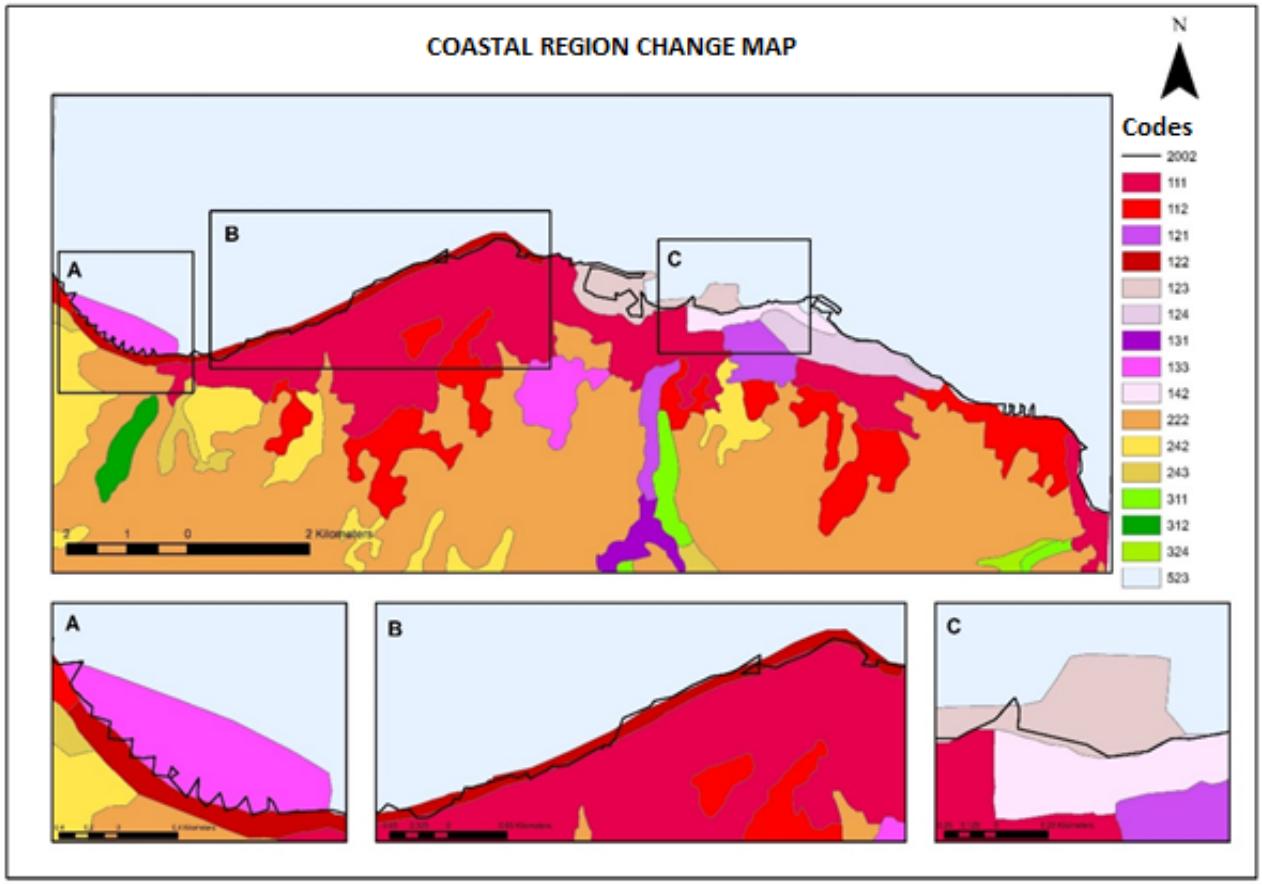

Figure 10. Demonstration of the change of coastal usage areas together with the coastline.

Area codes used in land use maps are explained in Table 4.

Table 4. Trabzon coastline land use Corine data.

Base Class	Codes	Sub-class
Structures	111	Continuous City Structure
	112	Discrete City Structure
	121	Industrial or Commercial Areas
	122	Road or Railroad Areas
	123	ports
	124	Airports
	131	Mining Fields
	133	Construction Sites
	142	Sports and Recreation Areas
	222	Orchards

Agricultural areas	242	Mixed Agricultural Fields
	243	Agricultural Areas With Natural Vegetation
Forest and	311	Broad Leaf Forests
Natural	312	Coniferous Forests
Areas	324	Plant Exchange Areas
Water Areas	523	Sea and Oceans

CONCLUSION

Change analyses are essential for monitoring spatial and temporal variations in land use, area size, and land characteristics. Understanding coastal change is particularly important, as it directly affects the physical and socio-economic conditions of communities residing along the shoreline. The results of this study indicate that coastline change has influenced urban development patterns, and that land reclamation activities extending toward the sea have created new areas of use within the coastal zone. In this context, RS techniques and GIS have been used effectively to detect temporal and spatial changes. Information about the land use of temporally changing areas was analysed with Corine data bases. Corine has been used as an efficient resource in change analysis, thanks to the spatial cartographic infrastructure of the Corine data and the effective classification of the attribute data.

In Trabzon, the mountains rise right after the sea, and the settlements originating from this mountainous area are scattered in the villages, while they are very close to the coastal coast. Settlements cause unplanned urbanization and the sea fill constructions done in order to gain space has provided a new place for the coastal area. The change of the coastal areas of Trabzon in the last 19 years has been obtained by determining the coastline of different years with different satellite images. Using Landsat satellite images, 142.18 hectares of land between 2002-2009, 61.34 hectares between 2009-2015, 56.76 hectares between 2015-2021, a total of 260.30 hectares of land between 2002-2021 detected. Using Google Earth satellite images, it has been determined that an area of 162.62 hectares between 2002-2012 and 72.44 hectares between 2012-2021 and a total area of 235.06 hectares between 2002-2021. It was concluded that the areal change caused land use change. Most of the areas changed are the filling areas made into the sea. It has been determined that the filled coastal areas have been transformed into sports and recreation areas, highway and port areas.

Consequently, coastlines can undergo rapid changes due to various human-driven alterations. Therefore, assessing these interventions is crucial for planning more orderly and sustainable coastal environments for the future.

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