



Monitoring the change of Turkey's tourism city Antalya's Konyaaltı shoreline with multi-source satellite and meteorological data

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Received: 5 June 2021 / Accepted: 13 March 2022 / Published online: 25 March 2022
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Abstract

Uncontrolled tourism activities cause the destruction of nature and deterioration of the ecological balance. Since coastal areas are both economically and socially important, monitoring shoreline changes has become one of the important research areas. Monitoring short-term and long-term changes in coastal areas is important to prevent damages that may occur due to natural and human factors and protect the shorelines. In this study, which is an important tourist city of Antalya, Turkey, and the world, coastal changes using historical and recent satellite data have been analyzed. The focus of the study is to analyze long-term coastal change with Landsat data and the data obtained every 5 years between 1985 and 2020 and to analyze short-term change with annual Sentinel-2 data between 2015 and 2020. In the study, water areas on the coastline were determined by object-based classification and multiresolution segmentation method with the Modified Normalized Difference Water Index (MNDWI). The obtained shorelines were analyzed with the Digital Shoreline Analysis System (DSAS) tool and the changes in the coastal areas were determined statistically. Five-year and 35-year changes were compared with Linear Regression Rate (LRR) and End Point Rate (EPR) analyses. As a result of the study, when the Pearson's r value between EPR and LRR was examined, r was found 0.916 and 0.944 for 5-year and 35-year data, respectively. Spatial resolution in satellite images is vital for shoreline detection. However, the most optimal way to detect long-term changes in the shoreline is to use Landsat data. Although the spatial resolution of Landsat data, it has been observed that the power to analyze annual variation differences is lower than Sentinel-2.

Keywords Sentinel-2 · Landsat · Shoreline change · Konyaaltı shoreline · DSAS

Introduction

Tourism, which is one of the industries showing a fast and steady development, emerges as an industry that needs natural, environmental, and cultural resources and uses these resources as economic input (Duran 2011; Ko and Stewart 2002; Ahmad et. al. 2018; Dunets et. al. 2019). The environmental impact is an important factor in increasing the likelihood of tourists to choose, as well as creating a sustainable tourism need for a specific region or country (Dunets and Zhogova 2018). In this respect, there is an important relationship between tourism and physical environment (Lo

et al. 2019; Jackman et al. 2020). While positive factors in the physical environment stimulate tourism activities, negative factors are a threat to tourism. For this reason, protecting the natural environment and optimizing physical conditions increase tourism activities (Dipova 2011; Uzunca et al. 2018).

The tourism sector, which grows uncontrollably, consumes natural areas and the resources it offers (Kim and Koo 2020). It is observed that the natural soil and water quality in the region has changed due to the increase in touristic needs especially during the holiday seasons (Wang and Tan 2020; Snyman and Bricker 2019). In Antalya (Turkey), which is one of the important tourism areas with a coast to the Mediterranean, agricultural and forest areas are destroyed due to the increase in tourism activities and tourism activities are carried out in these areas (Çetintürk 2016; Fleck 2018). In addition, coastal areas are also seriously affected in these areas as well as agricultural and forest areas. This transformation on the shorelines has attracted attention from the past

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and has been a topic that many researchers have focused on (Jiao 2007; Moreno-Izquierdo et al. 2019).

Coasts are places where water and land meet and are important places for nature and people. Coasts, especially in recent years, have become the focus of development all over the world and have undergone constant change as a result of human activities and natural events. Especially the beaches have attracted considerable attention as recreation areas, but the erosion that occurred on these coasts has become an important problem (Gormsen 1997; Phillips and Jones 2006; Page et al. 2017). Coastal regions, under the influence of various external factors such as wind, waves, currents that affect them and various factors such as rivers feeding them and various factors that cause material loss from them, in a process that can be expressed in thousands of years, it reaches a dynamic balance in terms of transport solids such as sand, gravel, silt, and clay (sediment) (Glover and Robertson 1998; Geyer et al. 2004; Mahmoodi et al. 2020). Thus, unless a factor to disturb the coastal balance is effective, significant erosion (coastal recession) or agglomeration (coastal progression) will not be encountered on the coasts. The most important factors that disrupt the dynamic balance of the coast are either natural factors such as the formation of large storms as a result of abnormal changes in the seasons or artificial (human-made) factors that occur as a result of various human activities. While the effects of natural factors manifest in long periods of decades, the results of human factors can be seen in short periods of a few years or even months (Xoplaki et al. 2001; Kireeva et al. 2020). It is necessary to determine this change occurring on the coasts and if these changes cause problems, measures should be taken. Satellite technologies are preferred due to the fact that these changes, which can occur annually, seasonally and even daily, are quite time consuming and inconvenient to measure with classical optical measurement methods (Ali et al. 2016; Carr et al. 2017; Bevacqua et al. 2018; Abdullah et al. 2019).

Remotely sensed satellite images are widely used to track the position of coastal areas and shoreline. Remote sensing data provide reasonable accuracy in shoreline determination and analysis of temporal changes (Jana et al. 2017). Satellite data has been shared free of charge with researchers and users since 1972 for Landsat and 2014 for Sentinel. Analysis of the temporal variation of the shoreline has been studied by many scholars (Nassar et al. 2018; Qiao et al. 2018; Ciritci and Turk 2020; Al-Zubieri et al. 2020; Mondal et al. 2020; Otmani et al. 2020; Velsamy et al. 2020). When the literature is examined, studies with Landsat have increased because it has been published for a long time and is free of charge (Balopoulos et al. 1986; Ryu et al. 2002; Mitra et al. 2013). Changes that occur over a long period of time have been the subject of many studies. Hossain et al. (2016) used satellite images of Landsat TM and OLI sensors to evaluate the

dynamic model of the Domar Char coastline, a small coastal island of Bangladesh, between 1990 and 2015. Archana et al. (2012), used LANDSAT ETM (15–60 m spatial resolution), IRS LISS-I (70 m spatial resolution) and IRS LISS-III (23 m spatial resolution) to evaluate the dynamics of the Brahmaputra River in India between 1990 and 2008. Ciritci and Turk (2020) have made a Kalman filter based future shoreline prediction as well as the coastal change analysis using multi-time satellite images. Roy and Mahmood (2016) correlated satellite data with hydrological data to determine erosion and coastal accumulation in the Sandwip Island of Bangladesh between 1974 and 2014. Usha et al. (2015) examined the changes occurring along the coast of Tamil Nadu (India) based on remote sensing and geospatial techniques.

Multi-time monitoring of coastal areas allows us to decide whether the changes are consistent or not, and it is possible to examine time-dependent modifications in coastal areas by combining Geographic Information System (GIS) and Remote Sensing methods. The Digital Shoreline Analysis System (DSAS), used to evaluate the dynamics of coastal movements and developed by the United States Geological Survey (USGS) (Thieler and Danforth 1992), is a highly successful GIS tool (Nor et al. 2020). DSAS is based on measuring the change in the coastline by taking measurement sections perpendicular to the shore (Armah 2011; Ahmad and Lakhan 2012; Dewidar and Frihy 2010). DSAS uses models such as End Point Rate (EPR) (Sebat and Salloum 2018), Linear Regression Rate (LRR), Average of Rates (AOR) to calculate coastal change (Jonah et al. 2016). There are many examples where DSAS has been used to analyze the temporal-spatial change qualitatively and quantitatively in the shorelines (Kermani et al. 2016; Nassar et al. 2019; Gracy et al. 2022; Ghorai and Bhunia 2020; Dereli and Tercan 2020).

When the studies in the literature are examined, it is seen that long-term changes are frequently studied. However, in recent years, due to drought and humanitarian factors, besides long-term coastal changes, there have been serious changes during the year. Although Landsat data has been available free of charge for many years, its spatial resolution is lower than Sentinel 2. In studies examining monthly changes that do not cover long years, Sentinel 2 data is more useful than Landsat data thanks to the 5-day revisit time and 10 m spatial resolution.

Konyaalti beach is one of Turkey's most important coastal tourism areas. Therefore, it has vital importance to observe the Konyaalti coastline and to take precautions against any possible negativity. The most important impacts caused by human contribution in the region are the mining activities carried out in the regions close to the Konyaalti coast (Dipova 2016). In this study, it is aimed to determine the coastal erosion that occurred in Antalya-Konyaalti shoreline. In addition, the performances of Landsat with 30 m spatial

resolution and Sentinel 2 data with 10 m spatial resolution were compared in detecting the change in coastal areas. In the study, coastal areas were determined using MNDWI and object-based classification method. For this, Sentinel 2 data from 2015 to 2020 and Landsat satellite data between 1985 and 2020 were used. Since optical images were used, topographic data could not be used for the study area. In addition, temperature, precipitation, and wind data recorded by the devices that measure in the region and obtained from the Turkish State Meteorological Service were used to strengthen the analysis results. In accordance with the methodology, for the coastlines analyzed by DSAS, two different satellite data were analyzed using EPR and LRR methods. Transect values were generated for the coasts analyzed with DSAS. For this reason, the change in the Boğa river in the Konyaaltı coastline in recent years is very important. It is necessary to create a baseline to monitor changes in coastal lines. There are three different methods to create a baseline. These are creating a line at a distance from the shoreline, using an old shoreline, and the method of creating a buffer. The third method is the most reliable and accurate method as it has the same shape as the closest shoreline, therefore this method was used to create a baseline in the present study (Nassar et al. 2019; Nandi et al. 2016).

Material and method

Study area

When we speak about tourism in Turkey, Antalya is one of the cities that come to mind. Its natural and human resources, various accommodation facilities, and good transport integration are effective in high demand (Sütcü et al. 2020). However, due to the COVID-19 pandemic that took effect in 2020, the tourism sector was significantly affected all over the world and the number of tourists coming to countries decreased in parallel (Fig. 1).

More than half a century has passed since the start of tourism activities in Antalya. The efforts to improve the attraction opportunities of Antalya started from the beaches. Since the 1950s, both existing beaches have been renewed and their number has been increased by building new modern beaches (Kapan and Timor 2018). In particular, the infrastructure of Konyaaltı and Lara beaches located in the city center has been created with priority. Konyaaltı Beach, which is one of the two important beaches of the city, has developed before due to its being intertwined with the city center and not having access problems (Yılmaz et al. 2020).

Konyaaltı beach is a blue flag public beach with a total length of 7 km and a length of 4.5 km and a width of 70 m (Fig. 2). The east–west length of the beach is 1.5 km and its

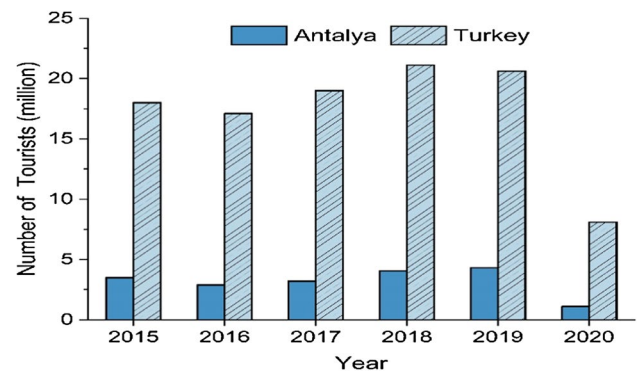


Fig. 1 The number of visitors coming to Turkey and through airline (KTB (Republican of Türkiye Ministry of Culture and Tourism), 2020)

width in the north–south direction varies between 10 and 40 m. Its natural boundaries are the Boğa river in the west and the cliffs in the east.

Being a natural symbol for Antalya, Konyaaltı cliff is one of the most important natural formations that manifest itself in the coastal part of the city as a Natural Protected Area. In 1979, these cliffs were designated as first degree natural protected areas and the natural protected area was revised in 1998 (Dipova 2016). The cliffs have both positive and negative effects on tourism activities. The most important of its positive effects is that it gives Antalya a unique appearance, air flow that provided and increases the quality of the landscape. The negative effects can be listed as the fact that the city–sea connection cannot be established outside of Konyaaltı and Lara beaches (because it is located at cliffs), it is unstable as a rock type, the construction on them for tourism purposes and parallel to the shore creates a barrier in front of the air flow and the city texture is deteriorated. The topographic structure of the city of Antalya, located on the southern edge of the Western Taurus Mountains, has a distribution of narrow coastal plains and high mountain ranges behind them (Sarı 2007). Extensions of the important mountain ranges of the Mediterranean Region go as far as the Antalya Plain. The altitude varies from 600 m to 2,500 m. There are Aksu delta and Yamansaz plains in the east of Antalya city and alluvial plains formed by Boğa river in the west (Dipova 2011). Konyaaltı beach was formed by the accumulation of alluviums brought by Boğa river in coastal areas and forming them by waves and streams (Sarı 2007). Konyaaltı Beach is not only important for the city of Antalya, is also an important beach for Turkey and the world. The most important feature that distinguishes Konyaaltı Beach from others is the extraordinary natural beauty gained by the geography behind the coast. In this context, when Beydağları and Konyaaltı Beach are considered together, it is one of the rare coastal areas with natural landscape character.

Fig. 2 Study area



Due to sediment transport, apart from the stable morphology that will occur on the shore in the long term, some changes in coastal morphology may occur over many years due to erosion or accumulation in a coastal region. These changes may occur due to natural and human-induced reasons. Since the coasts are dynamic environments, the shorelines are also subject to change over time, and these lines should be determined at certain time intervals. Satellite images are increasingly used as well as various conventional topographic measurements for the identification and tracking of the shoreline changes.

Konyaalti coastal erosion

Tectonic forces played an important role in the geological evolution of the region that includes the Konyaalti coast. With the tectonic effects in the Anatolian peninsula, the Anatolian block moved to the west, and after the compressional regime and before the Holocene, the continent caused to descend in the west and rise in the east (Glover and Robertson 1998). The western part, which includes the Teke Peninsula, consists of drowned (sunken) coastal structures. In the eastern part, the eustatic sea level rise was met by the rise of the land and lagoon formation did not occur except for a few limited areas. As a result of sea level rise and tectonically induced sinking, the old land topography in the Teke Peninsula 6000 years ago turned into coves and gulfs with drowned coastal structures (Öner et al. 1997; Dipova 2019). The sea started to fill these coves and gulfs with the alluvium carried by the streams, lagoons were formed, and as a result, coastal plains, which are swamps in places, were formed.

In parallel with the population growth and tourism construction in Antalya, a large amount of aggregate (sand-gravel) need has emerged since the end of the 1980s. This demand was met from the Boğa river basin, which is closest to the city center. However, many negativities were experienced in practice during this period. Operational defects created negative environmental impacts in settlements established near Boğa river basin (Aka 2007). The removal of material from large areas caused the riverbed to move. It was observed that material was taken without complying with the boundaries of the quarry (the quarries were operated up to a depth of 10 m and the material was taken) and ponds occurred due to excessive lowering of the elevation. The intake of sand and gravel in Boğa river, which has been continued for many years, decreased the sediment source and negatively changed the coastal balance and caused erosion on the shore.

In the 2000s, coastal erosion problems have become visible in the eastern part of the Boğa river Bridge. Damages on the roads and pavements during the storm were tried to be temporarily resolved by using stone filling. After the storm that occurred in the winter of 2003, damages occurred along the seaside of the Antalya-Kemer highway parallel to Konyaalti Beach, especially around the Gürsu beach. Thereupon, a circular surface coastal wall was built on approximately 800 m of the beach (Dipova 2011).

Although purchasing of material from Boğa river has been stopped today, it is possible that the pits formed during the operation are filled and the sediment deficiency is experienced until the riverbed is restored (Dipova 2011).

When the surrounding mines are closed, the lake fills up again. Nature will repair itself as long as material is not taken from the riverbed. As a matter of fact, the pit continued to fill up until 2015 (Dipova 2016, 2019).

Data

In this study, Landsat satellite data were used to monitor the coastal change between 1985 and 2020 and Sentinel-2 satellite data to monitor the annual differences between 2015 and 2020. The Landsat satellite system was launched into space in 1972 to monitor natural resources on earth. Landsat satellites, known as the second generation, started in 1982 with the launch of Landsat 4. Thematic Mapper (TM) sensor is used in second generation Landsat satellites. The last Landsat satellite (Landsat 8) was launched on 11 February 2013. Unlike second generation satellites, Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensors were used in Landsat 8 satellite. In the study, 8 Landsat satellite data taken at 5-year intervals between 1985 and 2020 were used. The specifications of the satellite data used are given in Table 1. The Sentinel-2 mission consists of two polar orbit satellites that follow each other 180 degrees in the same orbit. Its temporal resolution is 10 days at the equator. However, since there are two satellites in orbit, data can be obtained every 5 days. The Sentinel-2 data used are given in Table 1.

Methodology

In this study, the shoreline changes of Konyaaltı coast were investigated in the last 5 years using Sentinel-2 satellite images and in the last 35 years using Landsat satellite images. In the study, spatial and temporal changes related to the coastal change were statistically analyzed and interpreted using DSAS (Fig. 3).

In the study, firstly, sea and land areas are separated from each other by object-based classification. There are many methods in the literature for detail extraction and object classification studies (Ma et al. 2017; Yiğit and Uysal 2019; Luo et al. 2021; Sarıtürk et al. 2020). The commonly used method for the classification of high-resolution images is object-based classification (Ge et al. 2014; Akbulut et al. 2018; Çömert et al. 2019). Pixel-based approaches work on each pixel and extract information from remotely sensed data based on spectral information only (Gupta and Bhauria 2014; Tehrani et al. 2014; Khatami et al. 2016; Louargant et al. 2018). Unlike pixel-based classification, the object-based classification method does not work directly on individual pixels. This method works through clusters of many pixels, meaningfully grouped by the segmentation process. It then uses these clusters instead of pixels as classification elements (Carleer and Wolff 2006). In this study, Multi-Resolution Segmentation methods have been utilized for the segmentation and extraction of shorelines. A dataset consisting of 14 digital satellite images was used for the evaluation of the proposed method.

Table 1 Specifications of satellite data used for the study

Sentinel-2					
Sensing date	Platform	Processing level	Tile number	Cloud cover of study area (%)	
26 Aug. 2015	Sentinel 2A	LEVEL-1C	T36STF	0	
30 Aug. 2016	Sentinel 2A	LEVEL-1C	T36STF	0	
25 Aug. 2017	Sentinel 2A	LEVEL-1C	T36STF	0	
30 Aug. 2018	Sentinel 2A	LEVEL-1C	T36STF	0	
30 Aug. 2019	Sentinel 2B	LEVEL-1C	T36STF	0	
25 June 2020	Sentinel 2A	LEVEL-1C	T36STF	0	
Landsat					
Sensing date	Mission	Path	Row	Cloud cover of study area (%)	
20 Aug. 1985	Landsat 5	178	034	0	
02 Aug. 1990	Landsat 5	178	034	0	
31 July 1995	Landsat 5	178	034	0	
05 Aug. 2000	Landsat 7	178	034	0	
19 Aug. 2005	Landsat 7	178	034	0	
30 June 2010	Landsat 7	178	034	0	
06 July 2015	Landsat 8	178	034	0	
04 Aug. 2020	Landsat 8	178	034	0	

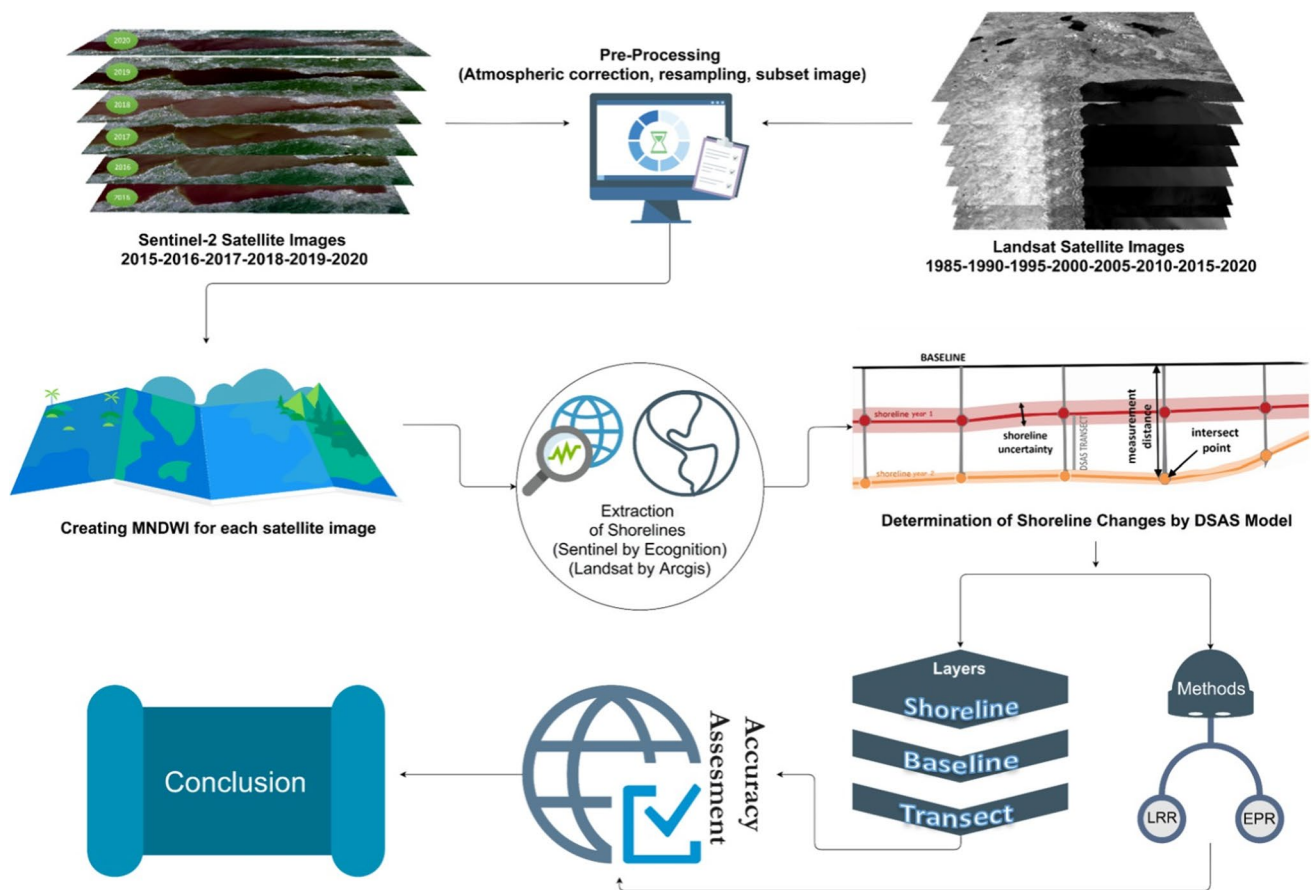


Fig. 3 Study workflow

MNDWI is good at distinguishing water areas by suppressing vegetation, soil noise and built-up noise. Water areas and settled areas are often mixed when using the NDWI index. So, water areas are really overestimated. Therefore, MNDWI is recommended in areas where built-up areas and water areas are mixed to reduce the built-up area noise above the NDWI. MNDWI is calculated by Eq. (1).

$$MNDWI = \frac{Green - SWIR}{Green + SWIR} \quad (1)$$

After the classification was completed, accuracy analysis was performed in the whole study area to determine how compatible the existing classes are with the reality of the place. In this study, the “Error matrix based on the TTA mask” approach is used. A confusion error matrix was produced by comparing the reference values of the selected test areas with the classification result, and the classification quality was tested. In this study, Recall (aka Sensitivity), specificity, F-measure, accuracy, and kappa index were used to evaluate the performance of the extracted shoreline. The exact definitions of these statistical measures have been detailed

in many studies (Chen et al. 2018; Orhan et al. 2020). They can be calculated using the following equations.

$$Sensitivity = \frac{TP}{TP + FN} \quad (2)$$

$$Specificity = \frac{TN}{TN + FP} \quad (3)$$

$$Accuracy = \frac{TN + TP}{TN + TP + FN + FP} \quad (4)$$

$$Positive\ predictive\ value = \frac{TP}{TP + FP} \quad (5)$$

$$Negative\ predictive\ value = \frac{TN}{TN + FN} \quad (6)$$

$$F - measure = \frac{2 * TP}{2 * TP + FN + FP} \quad (7)$$

$$\text{Kappa index} = \frac{(TP + TN) - [(TP + FN)(TP + FP) + (FP + TN)(FN + TN)] / (TP + FP + FN + TN)}{(TP + FP + FN + TN) - [(TP + FN)(TP + FP) + (FP + TN)(FN + TN)] / (TP + FP + FN + TN)} \quad (8)$$

where P is the total number of shorelines pixels and N is the total number of non-shorelines pixels; FP (false positive) and FN (false negative) are the numbers of pixels erroneously classified and TP (true positive) and TN (true negative) are the number of pixels that are correctly classified (Chen et al. 2017).

True-positive (TP): the shorelines pixels in the accurate class (Yes)

True-negative (TN): the non-shorelines pixels in the non-road class (No)

False-positive (FP): the non-shorelines pixels in shorelines class (Yes)

False-negative (FN): the shorelines pixels in non-shorelines class (No)

Extraction of shorelines

Assessment of shoreline using DSAS

To distinguish the coastal line from the sea and land areas, the MNDWI index was used, and the land areas were removed from the water areas. In this study, 5-year change between 2015 and 2020 with Sentinel-2 data and 35-year change between 1985 and 2020 with Landsat data were observed. Accordingly, the data classified using the MNDWI index was transformed into a polygon and the coastlines were extracted from the transformed polygon using ArcGIS software. Konyaalti beach, which is known to have a coastal change in recent years, and the shoreline that includes the Boğa river has been chosen as the coastline to be followed. When both Landsat and Sentinel data are examined, a visible difference emerges in the shoreline. In addition, the coastlines obtained from the two satellite images were analyzed and attention was paid to the harmony both within and between them. Accordingly, the coastlines were analyzed with DSAS tool, a tool that can be used in ArcGIS software and published by NASA.

EPR and LRR statistical approach was used to monitor and evaluate the position changes of shorelines. The EPR approach is simply calculated by dividing the distance separating the shoreline by the year difference between the dates of the shorelines. The simple mathematical model suggested for the EPR approach is given in Eq. (9) (Nassar et al. 2019; Dereli and Tercan 2020).

$$EPR = \frac{L_1 - L_2}{t_1 - t_2} \quad (9)$$

In the equation, L_1 and L_2 separate the distance between the shoreline, while t_1 and t_2 reveal the temporal difference between the shorelines.

Another mathematical approach, the LRR approach, is created by placing the least-squares regression line for a given transition at various points on multiple shorelines. It contains a simple calculation and is not complicated in terms of application and analysis. All shorelines are used for this calculation. The accuracy of the shoreline inferences is important for this analysis to give accurate and consistent results. Because the temporal resolution of these coastal changes directly affects the concepts that are important for the statistical method, such as the accuracy of the shoreline change rate (Nassar et al. 2019; Dereli and Tercan 2020; Ciritci and Turk 2020). Equation (10) was used for the LRR method (Nassar et al. 2019);

$$D = mt + a \quad (10)$$

In the equation, D refers to the distance from the baseline (m), t is the shoreline time changes (years), m is the slope of the placed line (m/year), and a is the intercept point of the y axis. In the linear regression method, the sample data are calculated with average distance values and this value is determined by minimizing.

In this study, the Konyaalti coastline was extracted with Sentinel-2 and Landsat 8 satellite images and the changes in the coastline were evaluated using the DSAS software according to EPR and LRR statistical methods and the relationship between them was investigated.

Results and discussion

The aim of the study is to determine the recent coastal change of the region and to reveal the factors that may cause the coastal change. Therefore, 10 m resolution Sentinel-2 satellite data broadcast free of charge by ESA and 30 m resolution Landsat data published by USGS were used separately for data acquisition. Thus, the effect of the resolution difference of the satellite image for coastal extraction is revealed. For this purpose, the “Error matrix based on the TTA mask” approach is used. A confusion error matrix was produced by comparing the reference values of the selected test areas with the classification result, and the classification quality was tested. Accuracy assessment values are given in Table 2 and Table 3.

Table 2 Accuracy assessment by error matrix-based analysis for Sentinel-2

Sentinel-2						
P	Year					
	2015	2016	2017	2018	2019	2020
TP	198	201	187	217	224	207
TN	197	199	185	216	223	206
FP	19	21	15	19	18	13
FN	20	22	16	25	19	15
Sensitivity	90.83%	90.13%	92.12%	89.67%	92.18%	93.24%
Specificity	91.20%	90.45%	92.50%	91.91%	92.53%	94.06%
Accuracy	91.01%	90.29%	92.31%	90.78%	92.36%	93.65%
F-measure	91.03%	90.34%	92.35%	90.79%	92.37%	93.67%
Kappa-index	82.03%	80.59%	84.62%	81.55%	84.71%	87.30%

P parameters

Landsat								
P	Year							
	1985	1990	1995	2000	2005	2010	2015	2020
TP	147	151	138	163	159	151	191	173
TN	142	147	129	159	156	147	186	169
FP	18	17	21	22	21	18	17	16
FN	19	15	24	23	24	21	18	18
Sensitivity	88.55%	90.96%	85.19%	87.63%	86.89%	87.79%	91.39%	90.58%
Specificity	88.75%	89.63%	86.00%	87.85%	88.14%	89.09%	91.63%	91.35%
Accuracy	88.65%	90.30%	85.58%	87.74%	87.50%	88.43%	91.50%	90.96%
F-measure	88.82%	90.42%	85.98%	87.87%	87.60%	88.56%	91.61%	91.05%
Kappa-index	77.30%	80.60%	71.13%	75.47%	75.00%	76.85%	83.01%	81.91%

P parameters

Table 3 Accuracy assessment by error matrix-based analysis for Landsat

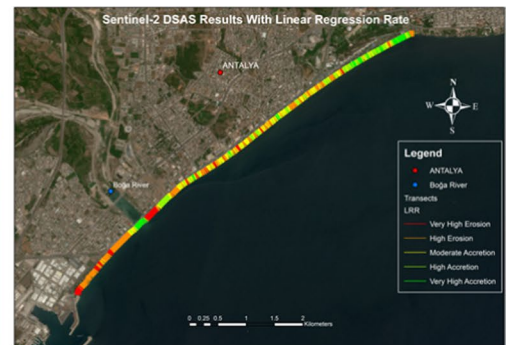
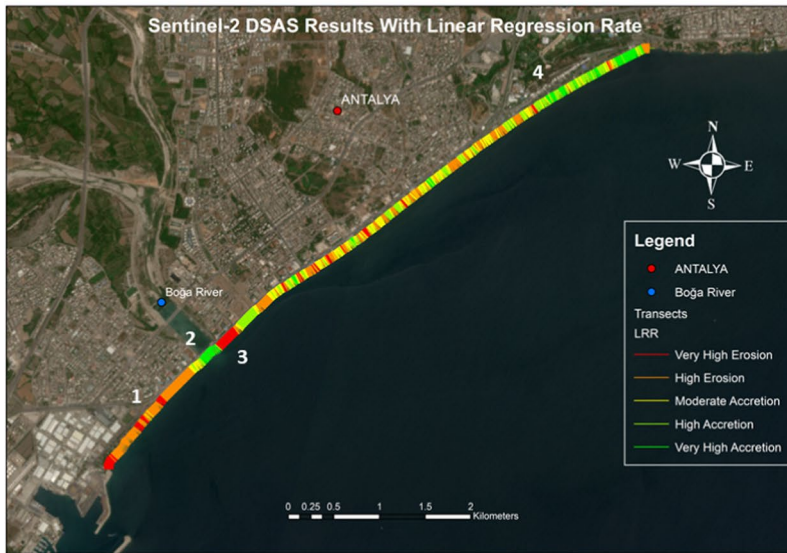


Fig. 4 Sentinel-2 data DSAS results with LRR and EPR statistics

Table 4 Statistical analysis of regional and all data in the study area

Zone	Segments	Descriptive statistics	90% confidence	
			EPR	LRR
1	141 segments	Maximum	0.03	0.56
		Minimum	-2.85	-2.35
		Mean	-0.25	-0.27
2	35 segments	Maximum	9.1	6.76
		Minimum	-0.02	0.51
		Mean	4.50	3.40
3	30 segments	Maximum	1.08	0.3
		Minimum	-0.01	-2.47
		Mean	0.08	-1.21
4	136 segments	Maximum	4.43	3.58
		Minimum	-1.93	-0.49
		Mean	1.41	1.89
All		Maximum	9.10	6.76
		Minimum	-2.85	-2.47
		Mean	0.52	0.76

The results show the higher performance of Sentinel satellite images than Landsat satellite images for object-based classification of the shore inference model (Sentinel lowest sensitivity 89.67% vs Landsat lowest sensitivity 85.19%).

Using the Landsat image to detect changes that occur in a short time is not suitable due to the low resolution. That is why 5-year interval data were used to draw more meaningful results from Landsat data. To provide DSAS parameters for both satellite data, a 50-m buffer was created based on all coastlines and specific parameters related to the baseline were added to the attribute table (SHAPE_Length, ID, Group, OFFshore and CasDir). However, the combined shoreline was added to another data named shoreline and specific parameters required for the DSAS tool were

added to the attribute table (SHAPE_Length, DATE_, UNCERTAINTY).

For the shoreline extracted from Landsat satellite images, a total of 779 transects were produced, 10 m apart and scanning an area of 120 m due to the serious change in the shoreline (Fig. 5). For the shoreline extracted from the Sentinel-2 satellite image, a total of 946 transects were produced at 10 m intervals and scanning an area of 100 m due to the serious change in the shoreline (Fig. 4). EPR and LRR values were generated from 90% confidence intervals for all transects. Regions important for significant change in the coastline were reserved for Sentinel-2 satellite data and their variation was examined separately (Table 4). While erosion is seen in zone 1 and 3, accretion is seen in zone 2 and 4. These zones were selected from areas with dense erosion and dense accretion. The reason for choosing the zones in this way is to obtain a more precise result.

It is not necessary to analyze the same regions in the analysis of historical data obtained with Landsat. Since the Landsat data dates to 35 years ago and there was no significant improvement in the shoreline from those days to the present (especially the Boğa river set and Antalya Port have further erosion the coastline), a continuous erosion is observed (Fig. 5).

For both data, the EPR and LRR values were evaluated linearly and the R^2 value was calculated as 83% for Sentinel-2 and 89% for Landsat. The R^2 value results evaluated differently. This difference occurred because Sentinel was calculated for a period of 5 years and Landsat for a period of 35 years. However, the correlation between the coasts was investigated with the Pearson’s r method and the correlation value for Sentinel-2 and Landsat was calculated as 92% and 94%, respectively (Figs. 6 and 7). The Pearson’s r method used because the method provides important information of the linear relationship between two

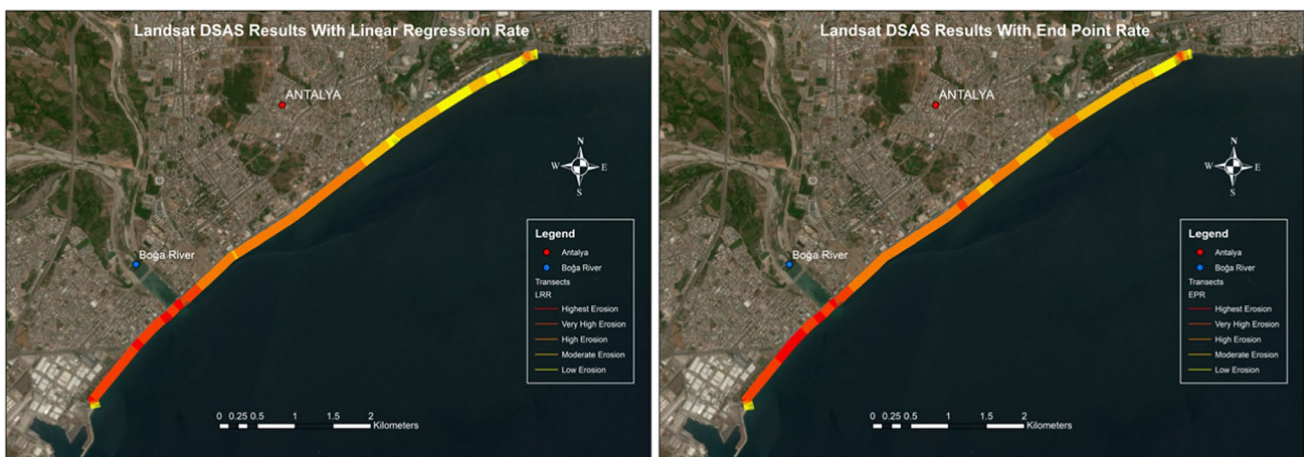
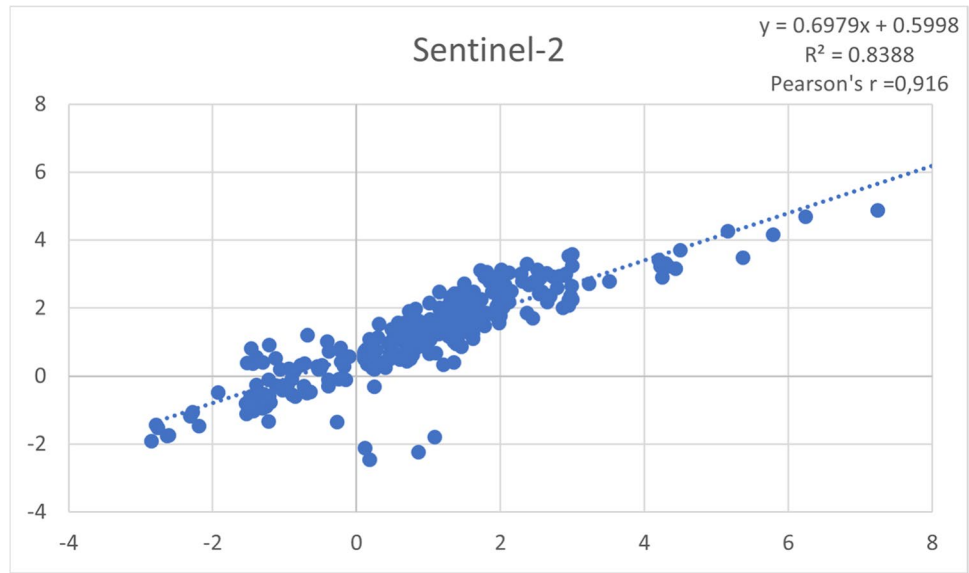


Fig. 5 Landsat data DSAS results with LRR and EPR statistics

Fig. 6 Correlation values between EPR and LRR according to R^2 and Pearson's r method for Sentinel-2 data



continual variables. Pearson's r is a statistical measure of the strength and direction of a linear association between two images. The Pearson's r value between two images is defined in Eq. (11):

$$r(A, B) = \frac{\sum m, n^{(A_{m,n} - \mu A)(B_{m,n} - \mu B)}}{\sqrt{\sum m, n^{(A_{m,n} - \mu A)^2} \sum (B_{m,n} - \mu B)^2}} \quad (11)$$

where μA and μB are the mean values of the two images (A and B), respectively. Pearson's r should be as close to one as possible. The difference between Pearson's r values will show how well the spatial quality is maintained (Sarp and Özcelik 2017). Thus, MNDWI spectral water index were

used in this study. In the MNDWI images, slight differences cannot be manually detected by visual inspection. Therefore, Pearson's r is measured among the different year's satellite images.

In addition to these, when 5-year meteorological data are examined, it is seen that the temperature averages are almost the same. Although there was a significant increase in the amount of precipitation in 2018 and 2019 in monthly and annual averages compared to 2016 and 2017 (Figs. 8 and 9), coastal erosion continued to be seen at the beach east of Boğa river (Fig. 4). Due to the increase in the amount of rainfall, filling was formed in Boğa river. However, while this filling is expected to fill the beach in

Fig. 7 Correlation values between EPR and LRR according to R^2 and Pearson's r method for Landsat data

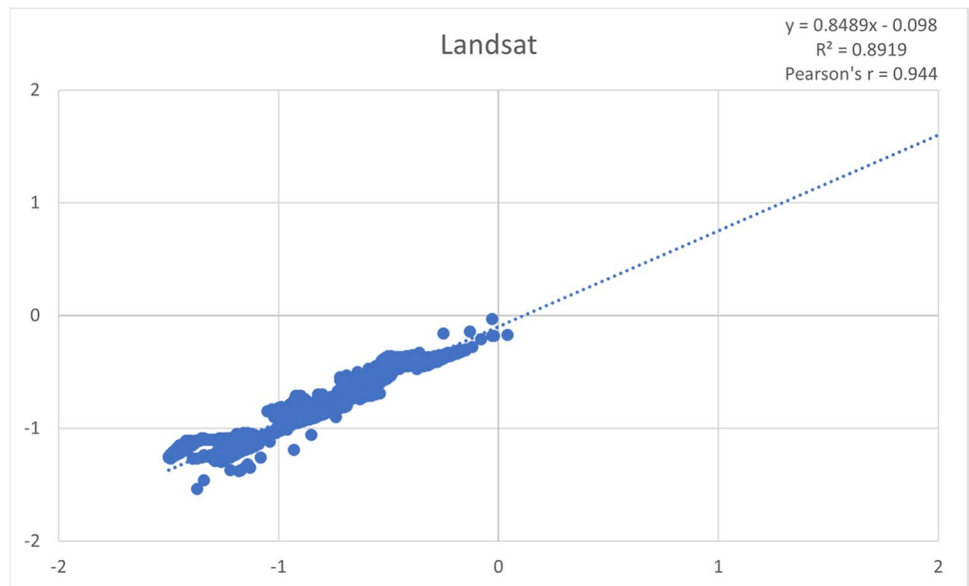
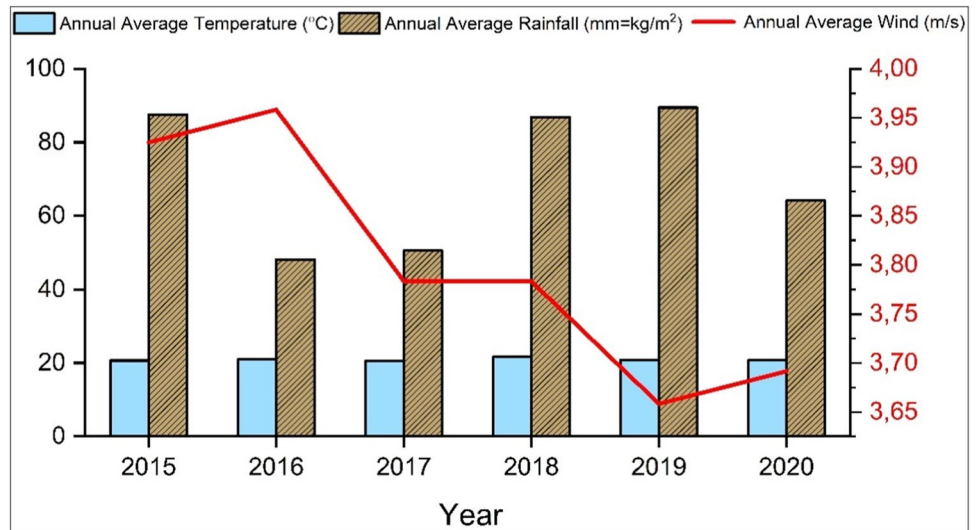


Fig. 8 Analysis of the annual average temperature, rainfall, and wind data of the Konyaalti coast (Turkish State Meteorological Service, 2021)



the east of the stream with wind waves, erosion is observed in this region in the same years.

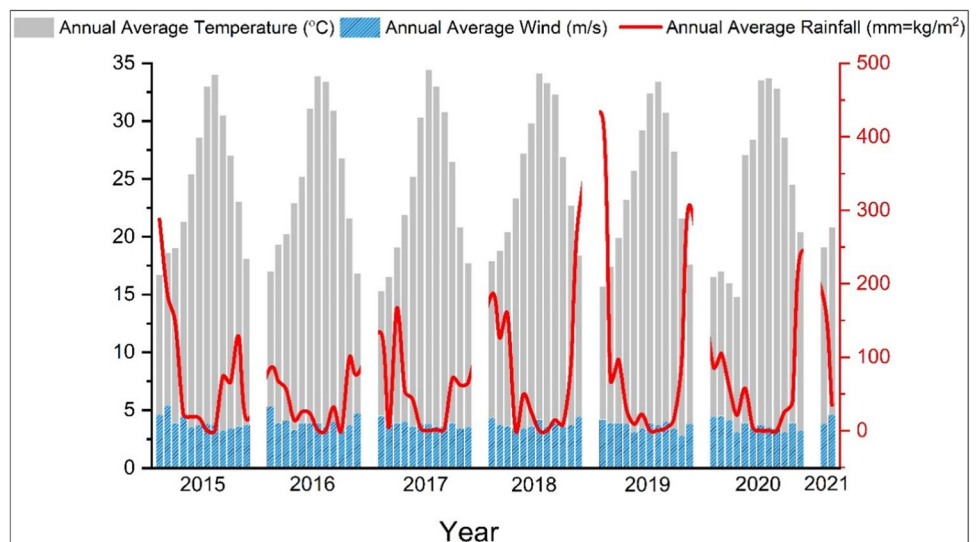
Conclusion

Coastal areas have been important to humanity throughout history. People have settled on lakes and rivers to their need for water and irrigation. Later, with the invention of ships, seas and oceans became important. Today, the coasts are one of the areas with rich natural resource potential, offering economic gain opportunities for people, and high development potential. In addition to all these, with the acceleration of tourism activities, the coasts have become more and more important. In addition to all these advantages, misuse of coasts and water resources caused by global warming causes the recession of seas and oceans,

shortening of the shoreline and damage to the biodiversity on the coasts. A large part of the world’s coasts is under threat due to reasons such as uncontrolled tourism activities, disruption of the biological balance on the coasts, and climate change. Serious changes occur in the coastal areas in a short time due to the introduction of the human factor.

In this study, in Antalya province of Turkey and one of the important tourist destinations for the world, multi-year coastal changes were analyzed. Using remotely sensed satellite data, two different shore changes with 5-year intervals and 1-year intervals were analyzed. Unlike the studies in the literature, this study compares the performance of satellite data by examining both 5-year and annual coastline changes with DSAS method. In the study, the 35-year change of the region was analyzed using 8 Landsat satellite data obtained in 5-year intervals between 1985 and 2020. In addition, to examine the short-term changes in recent years where the

Fig. 9 Examination of monthly average temperature, rainfall, and wind data of Konyaalti beach (Turkish State Meteorological Service, 2021)



tourism sector has gained momentum, the change in the region has been analyzed using 6 Sentinel-2 satellite data obtained annually between 2015 and 2020. It is seen that Landsat data cannot capture the annual changes due to the spatial resolution, but it is successful in 5-year changes. In addition, Sentinel-2 data, which has a spatial resolution of 10 m, successfully reveals the year-based coast changes. However, we cannot deny that Landsat data, which has provided data for many years, is especially important in revealing the differences in a few decades.

When the analysis results are examined, a significant amount of erosion was observed in both 35-year and 5-year changes (approximately 20 m erosion and 10 m accretion). Considering the meteorology data, even though there was more rainfall in 2018 and 2019 compared to other years, the fact that there was no accretion on the coastline reveals the impact of the human factor on nature. Thanks to the arrangements made in Boğa river in recent years, the riverbed has compensated for the current erosion. However, erosion continues to occur seriously on the coastline. Much longer time will be required for natural rehabilitation on shore. Meanwhile, actions that prevent material transport to the shore should be avoided. Since coastal erosion causes the change of the coastal line, previously built infrastructure facilities are also damaged by this process.

Acknowledgements The authors thank the Turkish State Meteorological Service for the meteorological data. The authors also thank the USGS and NASA for free satellite data.

Declarations

Conflict of interest The authors declare no competing interests.

References

- Abdullah AYM, Masrur A, Adnan MSG, Baky M, Al A, Hassan QK, Dewan A (2019) Spatio-temporal patterns of land use/land cover change in the heterogeneous coastal region of Bangladesh between 1990 and 2017. *Remote Sensing* 11(7):790
- Ahmad F, Draz MU, Su L, Ozturk I, Rauf A (2018) Tourism and environmental pollution: evidence from the one belt one road provinces of Western China. *Sustainability* 10(10):3520
- Ahmad SR, Lakhan VC (2012) GIS-based analysis and modeling of coastline advance and retreat along the coast of Guyana. *Mar Geodesy* 35(1):1–15
- Aka AS (2007) Konya şehrinin kuruluş ve gelişimini etkileyen coğrafi faktörler (Doctoral dissertation, Selçuk Üniversitesi Sosyal Bilimler Enstitüsü).
- Akbulut Z, Özdemir S, Acar H, Dihkan M, Karlı F (2018) Automatic extraction of building boundaries from high resolution images with active contour segmentation. *Int J Eng Geosci* 3(1):36–42. <https://doi.org/10.26833/ijeg.373152>
- Ali I, Cawkwell F, Dwyer E, Barrett B, Green S (2016) Satellite remote sensing of grasslands: from observation to management. *J Plant Ecol* 9(6):649–671
- Al-Zubieri AG, Ghandour IM, Bantan RA, Basaham AS (2020) Shoreline evolution between Al Lith and Ras Mahāsin on the Red Sea Coast, Saudi Arabia Using GIS and DSAS techniques. *J Indian Soc Remote Sens* 48(10):1455–1470
- Archana S, RD G, Nayan S (2012) RS-GIS based assessment of river dynamics of Brahmaputra River in India. *J Water Resour Protect* 4(2)
- Armah FAA (2011) GIS-based assessment of short term shoreline changes in the coastal erosion-sensitive zone of Accra, Ghana. *Res J Environ Sci* 5:643–654
- Bevacqua A, Yu D, Zhang Y (2018) Coastal vulnerability: evolving concepts in understanding vulnerable people and places. *Environ Sci Policy* 82:19–29
- Carleer AP, Wolff E (2006) “Region-based classification potential for land-cover classification with very high spatial resolution satellite data.” Pp. 4–5 in Proceedings of 1st International Conference on Object-based Image Analysis (OBIA 2006). Citeseer
- Carr MH, Robinson SP, Wahle C, Davis G, Kroll S, Murray S, ... & Williams M (2017) The central importance of ecological spatial connectivity to effective coastal marine protected areas and to meeting the challenges of climate change in the marine environment. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 27: 6-29
- Çetintürk İ (2016) Türkiye’de Sürdürülebilir Turizm Politikası (Issue October). Ekin Yayınevi
- Chen W, Peng J, Hong H, Shahabi H, Pradhan B, Liu J, Zhu AX, Pei X, Duan Z (2018) “Landslide susceptibility modelling using GIS-based machine learning techniques for Chongren County”, Jiangxi Province, China. *Sci Total Environ* 626:1121–1135
- Chen W, Pourghasemi HR, Panahi M, Kornejady A, Wang J, Xie X, Cao S (2017) Spatial prediction of landslide susceptibility using an adaptive neuro-fuzzy inference system combined with frequency ratio, generalized additive model, and support vector machine techniques. *Geomorphology* 297:69–85
- Ciritci D, Turk T (2020) Assessment of the Kalman filter-based future shoreline prediction method. *Int J Environ Sci Technol* 17:3801–3816
- Çömert R, Matcı DK, Avdan U (2019) Object based burned area mapping with random forest algorithm. *Int J Eng Geosci* 4(2):78–87. <https://doi.org/10.26833/ijeg.455595>
- Dereli MA, Tercan E (2020) Assessment of shoreline changes using historical satellite images and geospatial analysis along the Lake Salda in Turkey. *Earth Sci Inf* 13(3):709–718
- Dewidar KM, Frihy OE (2010) Automated techniques for quantification of beach change rates using Landsat series along the. *J Oceanogr Mar Sci* 1:28–39
- Dipova N (2011) Geotechnical characterization and facies change detection of the Bogacay coastal plain (Antalya, Turkey) soils. *Environ Earth Sci* 62(4):883–896. <https://doi.org/10.1007/s12665-010-0575-6>
- Dipova N (2016) Antalya Konyaaltı Sahilinde Kıyı Erozyonu Tehlikesi Coastal Erosion Hazard in Konyaaltı Beach, Antalya. *MAKÜ FEBED* 7(1):223–231
- Dipova N (2019) Boğaçay (Antalya) Rekreasyon Alanı Çalışmalarının Konyaaltı Sahiline Etkileri. 1(2): 71–76
- Dunets AN, Zhogova IG (2018) Significant changes of tourism industry in the altai-sayan mountainous region. *J Environ Manag Tour* 9(4(28)):868–878
- Dunets AN, Vakhrushev IB, Sukhova MG, Sokolov MS, Utkina KM, Shichiyakh RA (2019) Selection of strategic priorities for sustainable development of tourism in a mountain region: concentration of tourist infrastructure or nature-oriented tourism. *Entrep Sustain Issues* 7(2):1217

- Duran E (2011) Turizm, Kültür ve Kimlik İlişkisi; Turizmde Toplumsal ve Kültürel Kimliğin Sürdürülebilirliği. *SOSYAL BİLİMLER DERGİSİ* 10(19):291–313
- Balopoulos ET, Collins MB, James AE (1986) Satellite images and their use in the numerical modelling of coastal processes. *Int J Remote Sens* 7(7):905–919
- Fleck TG (2018) A public good under threat: coastal grabbing and the Coastal Shore Act in Gran Canaria, Canary Islands (Doctoral dissertation)
- Ge X, Sun X, Liu Z (2014) Object-oriented coastline classification and extraction from remote sensing imagery. In *Proc SPIE Int Soc Opt Eng* 9158:91580M
- Geyer WR, Hill PS, Kineke GC (2004) The transport, transformation and dispersal of sediment by buoyant coastal flows. *Cont Shelf Res* 24(7–8):927–949
- Ghorai D, Bhunia GS (2020) Automatic shoreline detection and its forecast: a case study on Dr. Abdul Kalam Island in the section of Bay of Bengal. *Geocarto International*. <https://doi.org/10.1080/10106049.2020.1815868>
- Glover C, Robertson A (1998) Neotectonic intersection of the Aegean and Cyprus tectonic arcs: extensional and strike-slip faulting in the Isparta Angle, SW Turkey. *Tectonophysics* 298(1–3):103–132
- Gormsen E (1997) The impact of tourism on coastal areas. *GeoJournal* 42(1):39–54
- Gracy Margret Mary R, Sundar V, Sannasiraj SA (2022) Analysis of shoreline change between inlets along the coast of Chennai, India. *Mar Georesour Geotechnol* 40(1):26–35
- Gupta N, Bhadauria HS (2014) Object based information extraction from high resolution satellite imagery using ECognition. *Int J Comput Sci Issues (IJCSI)* 11(3):139
- Hossain KT, Salaudinn M, Tanim IA (2016) Assessment of the dynamics of coastal island in Bangladesh using geospatial techniques: Domar Char. *J Asiat Soc Bangladesh Sci* 42(2):219–228
- Ryu J-H, Won J-S, Min K-D (2002) Waterline extraction from Landsat TM data in a tidal flat: a case study in Gomso Bay Korea. *Remote Sens Environ* 83:442–456
- Jackman M, Lorde T, Nairam S, Greenaway T (2020) Distance matters: the impact of physical and relative distance on pleasure tourists' length of stay in Barbados. *Ann Tour Res* 80:102794
- Jana A, Maiti S, Biswas A (2017) Appraisal of long-term shoreline oscillations from a part of coastal zones of Sundarban Delta, Eastern India – a study based on geospatial technology. *Spat Inf Res* 25(5):713–723. <https://doi.org/10.1007/s41324-017-0139-x>
- Jiao T (2007) *The Neolithic of southeast China: cultural transformation and regional interaction on the coast*. Cambria Press
- Jonah FE, Boateng I, Osman A, Shimba MJ, Mensah EA, Adu-Boahen K, Chuku EO, Effah E (2016) Shoreline change analysis using end point rate and net shoreline movement statistics: An application to Elmina, Cape Coast and Moree section of Ghana's coast. *Reg Stud Mar Sci* 7:19–31
- Kapan K, Timor AN (2018) Turizm gelişme modelleri açısından Antalya şehri. *Türk Coğrafya Dergisi* 71:53–61
- Kermani S, Boutiba M, Guendouz M, Guettouche MS, Khelfani D (2016) Detection and analysis of shoreline changes using geospatial tools and automatic computation: Case of jjelian sandy coast (East Algeria). *Ocean Coast Manag* 132:46–58
- Khatami R, Mountrakis G, Stehman SV (2016) A meta-analysis of remote sensing research on supervised pixel-based land-cover image classification processes: general guidelines for practitioners and future research. *Remote Sens Environ* 177:89–100
- Kim M, Koo DW (2020) Visitors' pro-environmental behavior and the underlying motivations for natural environment: merging dual concern theory and attachment theory. *J Retail Consum Serv* 56:102147
- Kireeva M, Frolova N, Rets E, Samsonov T, Entin A, Kharlamov M, Telegina E, Povalishnikova E (2020) Evaluating climate and water regime transformation in the European part of Russia using observation and reanalysis data for the 1945–2015 period. *International J River Basin Manag* 18(4):491–502
- Ko DW, Stewart WP (2002) A structural equation model of residents' attitudes for tourism development. *Tour Manag* 23(5):521–530
- KTB (2020) Republic of Turkey Ministry of Culture and Tourism. <https://yigm.ktb.gov.tr/>
- Lo MC, Chin CH, Law FY (2019) Tourists' perspectives on hard and soft services toward rural tourism destination competitiveness: community support as a moderator. *Tour Hosp Res* 19(2):139–157
- Louargant M, Jones G, Faroux R, Paoli J, Maillot T, Gée C, Villette S (2018) Unsupervised classification algorithm for early weed detection in row-crops by combining spatial and spectral information. *Remote Sens* 10(5):761
- Luo W, Xing J, Milan A, Zhang X, Liu W, Kim TK (2021) Multiple object tracking: A literature review. *Artif Intell* 293:103448
- Ma L, Li M, Ma X, Cheng L, Peijun Du, Liu Y (2017) A review of supervised object-based land-cover image classification. *ISPRS J Photogramm Remote Sens* 130:277–293
- Mahmoodi A, Lashteh Neshaei MA, Mansouri A, Shafai Bejestan M (2020) Study of current-and wave-induced sediment transport in the Nowshahr Port entrance channel by using numerical modeling and field measurements. *J Mar Sci Eng* 8(4):284
- Mitra SS, Santra A, Mitra D (2013) Change detection analysis of the shoreline using Toposheet and Satellite Image: a case study of the coastal stretch of Mandarmani-Shankarpur, West Bengal, India. *Int J Geomatics Geosci* 3(3):425
- Mondal I, Thakur S, Juliev M, Bandyopadhyay J, De TK (2020) Spatio-temporal modelling of shoreline migration in Sagar Island, West Bengal, India. *J Coast Conserv* 24(4):1–20
- Moreno-Izquierdo L, Ramón-Rodríguez AB, Such-Devesa MJ, Perles-Ribes JF (2019) Tourist environment and online reputation as a generator of added value in the sharing economy: the case of Airbnb in urban and sun-and-beach holiday destinations. *J Destin Mark Manag* 11:53–66
- Nandi S, Ghosh M, Kundu A, Dutta D, Baksi M (2016) Shoreline shifting and its prediction using remote sensing and GIS techniques: a case study of Sagar Island, West Bengal (India). *J Coast Conserv* 20(1):61–80
- Nassar K, Fath H, Mahmud WE, Masria A, Nadaoka K, Negm A (2018) Automatic detection of shoreline change: case of North Sinai coast, Egypt. *J Coast Conserv*. <https://doi.org/10.1007/s11852-018-0613-1>
- Nassar K, Mahmud WE, Fath H, Masria A, Nadaoka K, Negm A (2019) Shoreline change detection using DSAS technique: case of North Sinai coast. *Mar Georesour Geotechnol* 37(1):81–95
- Nor NAM, Tahar KN, Suprijo T, Sulaiman SAH (2020) Shoreline changes analysis along the coast of Kuala Terengganu, Malaysia using DSAS. In *2020 11th IEEE Control and System Graduate Research Colloquium (ICSGRC)* (pp. 276–281). IEEE
- Öner A, Demircin G, Ipekçioğlu H, Bülbül M, Ecin N (1997) Etiological and clinical patterns of urolithiasis in Turkish children. *Eur Urol* 31:453–458
- Orhan O, Bilgilioglu SS, Kaya Z, Ozcan AK, Bilgilioglu H (2020) Assessing and mapping landslide susceptibility using different machine learning methods. *Geocarto International* 1–26
- Otmani H, Belkessa R, Bengoufa S, Boukhediche W, Djerrai N, Abbad K (2020) Assessment of shoreline dynamics on the Eastern Coast of Algiers (Algeria): a spatiotemporal analysis using in situ measurements and geospatial tools. *Arab J Geosci* 13(3):1–15
- Page SJ, Hartwell H, Johns N, Fyall A, Ladkin A, Hemingway A (2017) Case study: Wellness, tourism and small business development in a UK coastal resort: public engagement in practice. *Tour Manage* 60:466–477

- Phillips MR, Jones AL (2006) Erosion and tourism infrastructure in the coastal zone: problems, consequences and management. *Tour Manage* 27(3):517–524
- Qiao G, Mi H, Wang W, Tong X, Li Z, Li T et al (2018) 55-year (1960–2015) spatiotemporal shoreline change analysis using historical DISP and Landsat time series data in Shanghai. *Int J Appl Earth Obs Geoinf* 68:238–251. <https://doi.org/10.1016/j.jag.2018.02.009>
- Roy S, Mahmood R (2016) Monitoring shoreline dynamics using Landsat and hydrological data: A case study of Sandwip island of Bangladesh. *The Pennsylvania Geographer* 54(2):20–41
- Sarı C (2007) “Antalya’nın Alternatif Turizm Kaynakları”, Akdeniz Üniversitesi Atatürk İlkeleri ve İnkılap Tarihi Araştırma Merkezi Müdürlüğü Yayınları, 20. Yüzyılda Antalya Sempozyumu, Antalya, 473–495
- Sariturk B, Bayram B, Duran Z, Seker DZ (2020) Feature extraction from satellite images using Segnet and fully convolutional networks (Fcn). *Int J Eng Geosci* 5(3):138–143. <https://doi.org/10.26833/ijeg.645426>
- Sarp G, Ozcelik M (2017) Water body extraction and change detection using time series: a case study of Lake Burdur, Turkey. *J Taibah Univ Sci* 11(3):381–391
- Sebat M, Salloum J (2018) Estimate the rate of shoreline change using the statistical analysis technique (EPR). *BIT VIII*(1):59–65
- Snyman S, Bricker KS (2019) Living on the edge: benefit-sharing from protected area tourism. *J Sustain Tour* 27(6):705–719
- Sütçü G, Oktay E, Aksöz, EO (2020) Conceptual study on tourist attraction of brand cities: Antalya And St. Petersburg cases. *J Tour Gastronomy Studies* 8(3):1608–1624
- Tehrany MS, Biswajeet P, Mustafa NJ (2014) A comparative assessment between object and pixel-based classification approaches for land use/land cover mapping using SPOT 5 imagery. *Geocarto Int* 29(4):351–369
- Thieler ER, Danforth WW (1992) Digital Shoreline Analysis System (DSAS) User’s Guide, Version 1.0; Open-File Report No. 92–355; United States Geological Survey Reston: Reston, VA, USA, p. 42
- Usha N, Anitha P, Vishnunath R, Edwin G, Ferrer V (2015) Monitoring longterm shoreline changes along Tamil Nadu, India using geospatial techniques. *Aquatic Procedia* 4:325–332
- Uzunca B, Rigtering JC, Ozcan P (2018) Sharing and shaping: A cross-country comparison of how sharing economy firms shape their institutional environment to gain legitimacy. *Acad Manag Discov* 4(3):248–272
- Velsamy S, Balasubramaniyan G, Swaminathan B, Kesavan D (2020) Multi-decadal shoreline change analysis in coast of Thiruchendur Taluk, Thoothukudi district, Tamil Nadu, India, using remote sensing and DSAS techniques. *Arab J Geosci* 13(17):1–12
- Wang R, Tan R (2020) Efficiency and distribution of rural construction land marketization in contemporary China. *China Econ Rev* 60:101223
- Xoplaki E, Maheras P, Luterbacher J (2001) Variability of climate in meridional Balkans during the periods 1675–1715 and 1780–1830 and its impact on human life. *Clim Change* 48(4):581–615
- Yiğit AY, Uysal M (2019) Nesne Tabanlı Sınıflandırma Yaklaşımı Kullanılarak Yolların Tespiti. *Türkiye Fotogrametri Dergisi* 1(1):17–24
- Yılmaz T, Olgun R, Serhat GÜL (2020) Evaluation of Antalya/Konyaaltı coastline in terms of user satisfaction. *Ibad Sosyal Bilimler Dergisi* 6:245–257