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Special Issue 2.2023

Burn or sink
Planning and managing the land

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Cover photo by Giuseppe Mazzeo. Rising wheat fields on the hills of Conza della Campania, Irpinia. January 31, 2023.

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Unveiling shoreline dynamics and remarkable accretion rates in Lake Eğirdir (Turkey) using DSAS. The implications of climate change on lakes

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Abstract

Lakes and their shorelines are important ecosystem areas with the diversity of living species they host. In addition, lakes are an almost indispensable resource for humans as a source of fresh water. Global climate change causes changes in lake surface conditions such as ice cover, surface temperature, evaporation, and water level. To understand the vulnerability of lakes to global climate change, researchers study the temporal rates of change that occur on lake shorelines. Shoreline monitoring contributes to important steps such as lake shoreline management, shoreline change, erosion monitoring, flood forecasting, and water resource assessment. Therefore, in this study, Landsat ETM+ multi-temporal images of the east part of Isparta Eğirdir Lake were obtained and the change in the shoreline over a 10-year period (2013-2022) was examined using the DSAS (Digital Shoreline Analysis System) tool. As a result of the study, very high levels of accretion were observed in the entire 82 km area examined in Eğirdir Lake. The highest EPR (53.79 m/year) in transect ID 149 and the highest LRR (60.87 m/year) in transect ID 26 were observed. These values are well above the +2m/year EPR (End Point Rate) and LRR (Linear Regression Rate) values, which means very high accretion.

Keywords

Lakes; Shoreline monitoring; Climate change; DSAS; Accretion.

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1. Introduction

The shoreline represents the dynamic boundary between land and water, and shoreline change analysis refers to the methods and approaches used to study and quantify the shifts in shoreline positions over time, starting from the 1970s. While initially focused on coastal environments, shoreline change analysis has also been applied to lake shorelines, particularly in larger systems like the Great Lakes (such as Lake Erie, Lake Michigan, and Lake Tahoe) (Li et al., 2001; Adams & Minor, 2002; Kilibarda & Shillinglaw, 2015; Burningham & Fernandez-Nunez, 2020). Lakes are ecologically significant areas that harbor a wide array of living species. They play a vital role in influencing the local climate, serving as freshwater sources, and supporting agricultural activities (Aksoy et al., 2019). However, lakes are currently experiencing intensified disturbances of both natural and human origin. These include increased evaporation due to climate change and the unsustainable exploitation of resources (Nassar et al., 2019). Accordingly, urbanization, inadequate water management policies, industrial pollution, and the effects of climate change have necessitated a re-evaluation of water resources. This re-evaluation involves critically analyzing past protection and prevention plans, aiming to develop more effective strategies for safeguarding lakes and their ecosystems (Keskin et al., 2015).

Agricultural activities practiced in closed basins of Turkey greatly damage the lakes in the basin areas, under the conditions that the current precipitation situation is not considered. The ecosystem related to the lakes is also affected by the same amount of damage (Aksoy et al., 2019). In addition, urbanization and anthropogenic land use carried out indiscriminately in shoreline areas lead to problems such as soil degradation in the region (Mazzeo, 2020), water pollution, and local climate change (Dinç & Gül, 2021). The basic structure of the European Union (EU) Water Framework Directive dated 22 December 2000 is holistic watershed management, which is put forward as the main tool in achieving the directive's objectives. Holistic watershed management enables different sectors and resource users to be considered together, for long-term evaluation of threats and opportunities, and to monitor the positive and negative effects of an intervention in an area within the basin (European Parliament and Council, 2000).

Research is needed to narrow the uncertainties about climate change over the Great Lakes and about the sensitivities of the lakes and resources they support to climate. One of the most helpful components of future research on global warming and the Great Lakes would be better estimates of regional climate change (Smith, 1991). Monitoring the temporal variation of surface water and obtaining data on surface water dynamics are essential for policy and decision-making processes (Giardino et al., 2010; Sarp & Ozcelik, 2016). Monitoring the temporal-spatial changes of lakes can help to understand the spatial distribution of water level reduction, to predict development trends (Nassar et al., 2019), and support mechanism research on countermeasures against desertification. Further improvements in remote sensing (especially in small lakes) and in situ data are an important step toward improving global understanding of lake processes and their responses to climate change (Woolvay et al., 2020). In recent years, geographic information systems (GIS) and remote sensing data integration have been used in shoreline extraction and mapping (Frey et al., 2010; Pardo-Pascual et al., 2012; Sarp & Özçelik, 2017).

Significant recession can be observed in recent years on the shores of Lake Eğirdir, which is in the Lakes Region of southwestern Turkey and is the second largest freshwater lake in Turkey. Therefore, regular measurements of the lake shoreline are needed in future studies for a sound watershed management process and the determination of the right policy decisions. In this context, the aim of this study is to reveal the temporal changes on the eastern shore of Lake Eğirdir and conduct a situation analysis through the observation of these changes, while also identifying risk factors. This, in turn, contributes to comprehensive watershed management by enabling planners to take measures against the effects of climate change and ensure ecological sustainability. Factors such as agricultural activities and urbanization that disrupt the ecological system and result from human impacts in the lake basin system can be easily detected, and a rapid recovery process can be initiated when these impacts are mitigated. However, the observation of climate change, even leading to the drying of lakes, becomes challenging when considering the presence of anthropogenic effects, and once identified, it often leads to a difficult-to-reverse process. Therefore, this study aims to highlight the impact of drying in a region with minimal anthropogenic activities around a drying lake, enabling the early detection of the power of climate change.

This study focuses on the analysis of multi-temporal Landsat ETM+ images using automatic shoreline delineation and change detection techniques. The researchers employed the Modified Normalized Water Difference Index (MNDWI) to extract water areas from the Landsat ETM+ data. The MNDWI utilizes bands 3 and 6 of the satellite images to identify water bodies. The method allows for the analysis of shorelines extracted from multiple Landsat satellite images acquired at different times. By comparing the extracted shorelines, the study provides valuable data for investigating changes in shoreline positions over time. The MNDWI index has been previously tested and utilized in various applications, including surface water mapping and land use and land cover change analysis. Its effectiveness in these applications has contributed to its adoption in this study for shoreline analysis and change detection (Duan, 2013; Feyisa et al., 2014) land use and land cover change analysis (Davranche et al., 2010), and ecological research (Poulin et al., 2010, Sarp & Ozcelik, 2017).

Then, the changes in the shoreline were examined using the Digital Shoreline Analysis System (DSAS). The Digital Shoreline Analysis System (DSAS) GIS software extension was first originated by the USGS in the 1990s and is a useful system due to its seamless integration and accessibility within the ArcGIS framework (Burningham & Fernandez-Nunez, 2020). The quantitative dataset of shoreline change largely focuses on the derivation of five key measures (net shoreline movement [NSM], shoreline change envelope [SCE], endpoint rate [EPR], linear regression rate [LRR], and weighted LRR) (Burningham, & Fernandez-Nunez, 2020). The data obtained in the study were first graphed according to the NSM method. The NSM method reveals shoreline changes by measuring the total distance between the nearest shoreline and the earliest timeline at the time of measurement. According to the NMS method of the DSAS applied on the lake shore of Eğirdir, the average distance is 299.75 m, and the maximum distance is 484.13 m in the 26th Transect. Shoreline change trends were mapped according to the geometric interval of the EPR and LRR values. As a result of the study, it was revealed that there was a great change rate from 2013 to 2022 in the 82 km shoreline determined as the study area. In Lake Eğirdir, the accretion values were observed to be well above the +2m/year EPR (End Point Rate) and LRR (Linear Regression Rate) values, which means very high accretion. This excessive accretion on the shore of Lake Eğirdir is largely associated with Climate Change by the author. Global climate change is widely acknowledged as a major catalyst for environmental transformations, including shifts within lake ecosystems. The effects of climate change, such as rising temperatures and changing precipitation patterns, have direct implications for lake dynamics. These changes can directly impact the rate of shoreline accretion, leading to notable alterations in the lake's boundary.

2. Study area

The Lakes Region extends to the provincial borders of Konya, Isparta, Burdur, Denizli, and Afyonkarahisar in the southwest of Anatolia. The Lakes region stands out not only with its wetland feature but also because it has been a significant settlement area since the Paleolithic Age (Uysal, 2018; Aksoy et al., 2019). Lake Eğirdir, a part of the Lakes region, is Turkey's second largest freshwater lake after Lake Beyşehir. The area of Lake Eğirdir is 62,621 hectares and the height of the area where it is located is 915 meters above sea level. The lake is within the scope of a natural protected area, and besides being a drinking water basin, it is a wetland with high biological diversity. While there are 514 different bird species in Europe and 454 in Turkey, 225 of the bird species in Turkey live in and around Lake Eğirdir (Aksoy et al., 2019).

The lake's recharge sources are precipitation falling on the lake area, drainage area runoff, and groundwater flow (including springs). Its discharge is through the lake bottom, evaporation, sinkholes, and artificial discharge (irrigation energy generation and drinking-utility water supply) at the southern end. The date of announcement of drinking and utility water of Lake Eğirdir is 26th February 1991 (Special Provisions of Lake Eğirdir, 2012).

The protection of Lake Eğirdir is carried out within the framework of the special provisions for Lake Eğirdir that came into effect in 2012. This protection consists of three zones: the absolute protection zone (30 m), the short-distance protection zone (700 m), and the mid-distance protection zone (1,000 m). The absolute protection zone includes the Lake Green Belt Area, the Geology-Based Absolute Protection Area, and the Lake Protection Areas. Within the absolute protection zone, the areas nourishing the lake, such as the Taşevi spring, Aşağıtırtar spring, Kemerdamları spring, along with the limestone surfaces that come into contact with the nourishment area, and Kayaağzı spring, are included. According to the regulations, all tree and plant species in the absolute protection zone are preserved. No construction or mining activities are allowed in this area. Furthermore, no new industrial establishments or tourism facilities are permitted in this area (Special Provisions of Lake Eğirdir, 2012).

It has been recently brought to the agenda by researchers that the water level in Lake Eğirdir is decreasing day by day. According to the study conducted by Aksoy et al., (2019), it is seen that there is a local water withdrawal of 300 m on the opposite shore of Akkeçili village (east of the central part of the lake). The southern part of the shoreline area covering the study area is used for agricultural activities, whereas the northern part exhibits natural vegetation, with no development or agricultural activity (Alp et al., 2020).

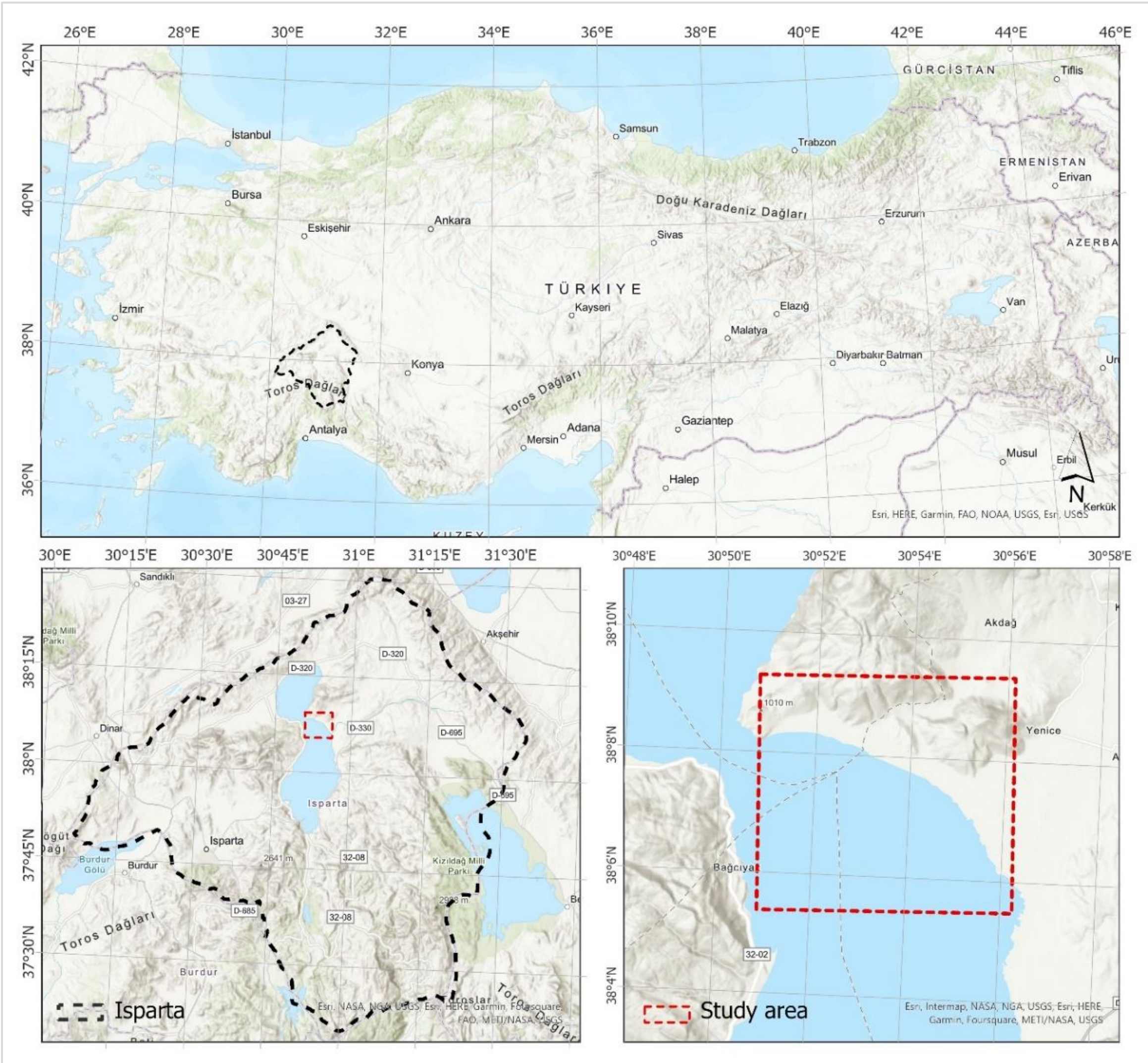

Fig.1 Study area (East shoreline of Eğirdir Lake, Isparta, Turkey)

The nearest settlement to this coast is Yenice village with a population of 870. The distance of Yenice village, located in the south of the study area, from the coast is approximately 4 km. Since agricultural activities and discharge are low in the area where intense withdrawal is observed in the middle part of the lake, the withdrawal observed along a line in this area is mostly associated with global climate change. Therefore, in this study, this shoreline in the east of the lake was examined (Fig.1).

3. Material and methods

This study utilized the Digital Shoreline Analysis System (DSAS) to assess shoreline changes along the eastern shore of Lake Eğirdir. The DSAS, developed by the United States Geological Survey (USGS), is a Geographic Information System (GIS)-based tool that enables the calculation of shoreline change rates using time series shoreline data. The DSAS implementation in this study involved six main steps: (1) data collection, (2) extraction of shorelines, (3) creation of a baseline, (4) generation of transects, (5) computation of distances between the baseline and shorelines at each transect, and (6) calculation of shoreline changes rates (Thieler et al., 2005). To perform these procedures, Landsat ETM+ satellite images of Lake Eğirdir were obtained for the years between 2013-2022. The process of collecting, processing, and comparing remote sensing satellite images obtained as research data involves ensuring a regular periodic dataset over a limited research period. In this context, the satellite images obtained in this study from 2013 to 2022 cover a period during which Landsat 7 ETM+ satellite images were accessible and provided a secure and comparable dataset for the examination of annual changes. Within this scope, a 10-year period has been considered appropriate for examining the changes along the lake shoreline in this study. The images, acquired at a spatial resolution of 30 meters, were selected based on availability, considering the challenges of obtaining cloud-free images for the necessary analysis at regular intervals. Subsequently, all satellite images were imported into ArcGIS software for shoreline digitization.

Modified Normalized Water Difference Index (MNDWI) was used to extract the shoreline from Landsat ETM+ satellite images. Shorelines represent the high-water line surveyed using GPS units in kinematical mode (Moore, 2000). The MNDWI method suggested by (Xu, 2006) has been commonly used and is a convincing index that can extract water bodies (Ji, Zhang & Wylie, 2009; Lu et al., 2011). It is expressed by equation (1).

$$MNDWI = \frac{band\ 3 - band\ 6}{band\ 3 + band\ 6} \tag{1}$$

Values in the water feature are positive in band 3 due to their higher reflectance than in band 6, and non-water features are in negative NDWI (Xu, 2006). A threshold value for MNDWI (e.g., simply a value of zero) is set to divide the MNDWI results into two classes (water and non-water properties).

After extracting the shorelines in the 10-year period starting from 2013 until 2022 (Fig.2), the baseline line was created by the buffering method. The method employed in this study for baseline delineation is considered highly valid and accurate. It adopts the sinuosity shape of the nearest shoreline, making it well-suited for creating the baseline in the analysis. By following the natural contours and curves of the shoreline, this approach ensures that the baseline accurately represents the land-water interface in the study area (Nandi et al., 2016; Nassar et al., 2019). Accordingly, the baseline in this study is established by creating a buffer zone at a distance of 150 meters from the nearest shoreline of the lake.

Then, transects that are cast perpendicular to the reference baseline were generated with DSAS to intersect shorelines at 50 m intervals alongshore. 165 sections were generated along the 82 km of the study area.

In the Digital Shoreline Analysis System (DSAS), the software calculates the distance between the established baseline and each intersection point where a shoreline intersects a transect section. By considering the date information and incorporating spatial uncertainty for each shoreline, DSAS generates change data.

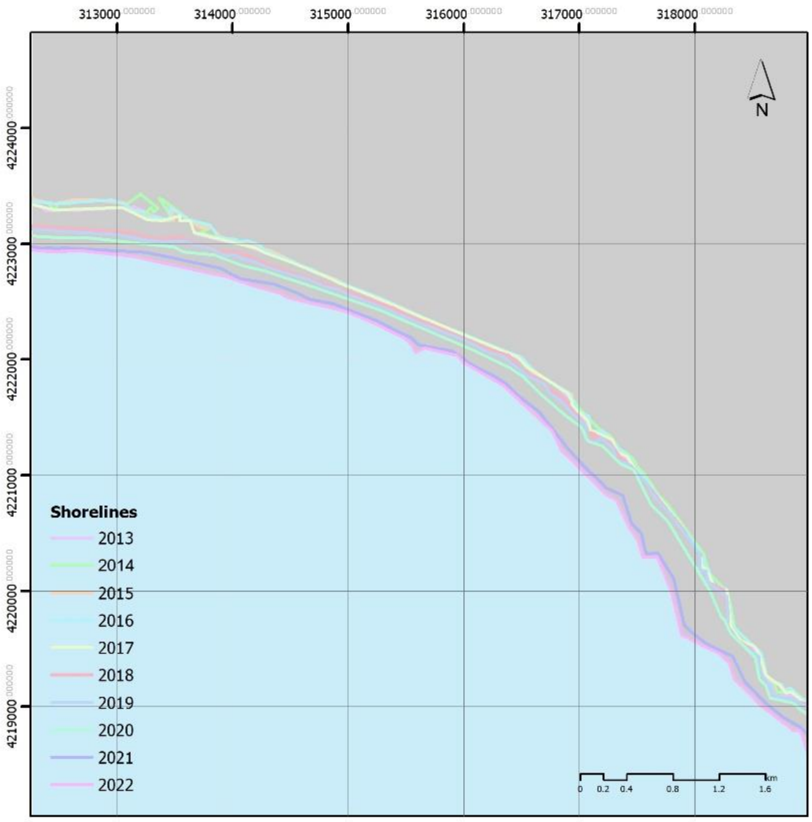

Fig.2 Multi-temporal shoreline data of Lake Eğirdir (2013-2022)

This process involves quantifying the distance between the baseline and shoreline intersections along designated sections. DSAS then combines this spatial information with the temporal data associated with each shoreline, considering the uncertainty or variability in the spatial measurements. By integrating these factors, DSAS provides comprehensive change data that considers both the spatial and temporal aspects of shoreline dynamics (Himmelstoss et al., 2022). DSAS generates a lot of statistical data to evaluate the change in the shoreline. These are Shoreline Change Envelope (SCE), Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression (LRR) (Thieler et al., 2009; Mutaqin, 2017).

SCE refers to the greatest distance between all shorelines without adding the year of the shoreline (Mutaqin, 2017). Net Shoreline Movement (NSM) is shoreline shift. Therefore, the NSM method shows how much the shoreline has changed, not the rate of change (Kurniawan & Marfai, 2020). EPR and LRR calculate shoreline change rate data for each transect. EPR refers to the shoreline shift distance divided by the time difference between the first and last shoreline (Mutaqin, 2017). The EPR is simply calculated by dividing the distance (m) separating the two shorelines by the number of the two shorelines between dates (Equation 2) (Nassar et al., 2019).

$$EPR = \frac{L_1 - L_2}{t_1 - t_2} \qquad (2)$$

In the EPR method, the distance between the shoreline and baseline is represented by L_1 and L_2. These values indicate the separation between the established baseline and the positions of two shorelines. Additionally, the dates of the two shoreline positions are denoted as t_1 and t_2, respectively (Nassar et al., 2019). LRR, on the other hand, is computed by fitting the least squares regression line to all shoreline points for a particular transect (Mutaqin, 2017). In this calculation, the method performs the fitting of a least squares regression line to multiple shoreline position points for transects (Nassar et al., 2019). The regression line is positioned in such a way that it minimizes the sum of squared residuals. These residuals are obtained by squaring the vertical distance between each data point and the regression line, and then summing up all the squared residuals. The linear regression rate, on the other hand, corresponds to the slope of the regression line (Himmelstoss et al., 2018; Singh et al. 2022).

Researchers focus on two types of shoreline changes namely accretion and erosion. As a result of DSAS, EPR, and LRR are obtained as positive and negative values, where a positive value indicates accretion of the shoreline and a negative value indicates erosion of the region (Mutaqin, 2017; Nassar et al., 2019; Singh et al., 2022). Erosion and accretion levels on the shorelines are classified according to Nassar et al. (2019) as in Tab.1.

Category	Rate of shoreline change (m/year)	Shoreline classification
1	>-2	Very high erosion
2	>-1 and <-2	High erosion
3	>0 and <-1	Moderate erosion
4	0	Stable
5	>0 and <+1	Moderate accretion
6	>+1 and <+2	High accretion
7	>+2	Very high accretion

Tab.1 Shoreline classification based on EPR and LRR

In this study, first, the total distance between the shoreline and the earliest time at the time of measurement was revealed by the NSM method to evaluate the change of the Eğirdir eastern shoreline. Then the change trends in the shoreline were demonstrated according to the EPR and LRR data. Finally, the effect of climate change on this change is discussed.

3. Results of the DSAS

NSM, EPR, and LRR data from the DSAS results made on the 82 km shoreline determined in Lake Eğirdir reveal the changes in the shoreline. Shoreline erosion refers to retreating towards the land or if the resulting NSM value is negative (Kurniawan & Marfai, 2020).

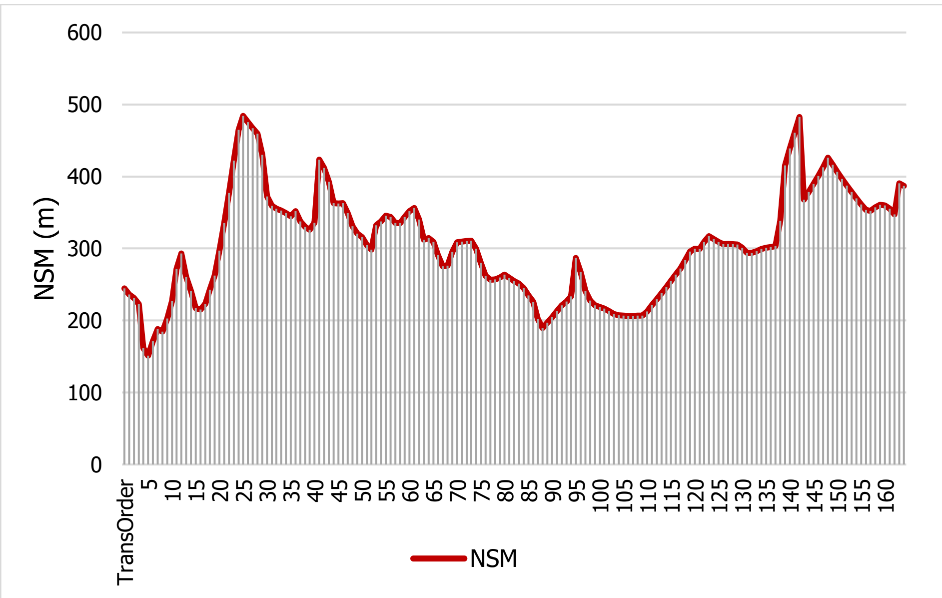

Fig.3 Net Shoreline Movement (NSM) of the Eğirdir Lake shoreline

Furthermore, the analysis of the Normalized Shoreline Movement (NSM) values allows us to observe shoreline behavior, particularly regarding accretion or erosion. Positive NSM values indicate shorelines that have expanded or advanced towards the lake, suggesting accretion. Conversely, negative NSM values indicate shoreline retreat or erosion.

In this study, the oldest shoreline considered is from 2013, while the most recent shoreline is from 2022. By calculating NSM values for each shoreline, the study examines the temporal changes and dynamics of the shoreline. The results, illustrated in Fig.3, provide valuable insights into the overall trend of shoreline evolution and whether it has experienced erosion or accretion over the specified time period. In terms of NSM, EPR, and LRR values, it is seen that there is accretion on the entire shoreline.

According to the NSM method of the DSAS applied on the lake shore of Eğirdir, the average distance is 299.75 m and, the maximum distance is 484.13 m in the 26th transect. In addition, all shoreline sections have positive distances.

Shoreline change trends were mapped according to the geometric interval of the EPR and LRR values in Fig.4 and Fig.5 respectively for the Shoreline of Eğirdir Lake. Geometrical interval generates class breaks based on class intervals that have a geometric series.

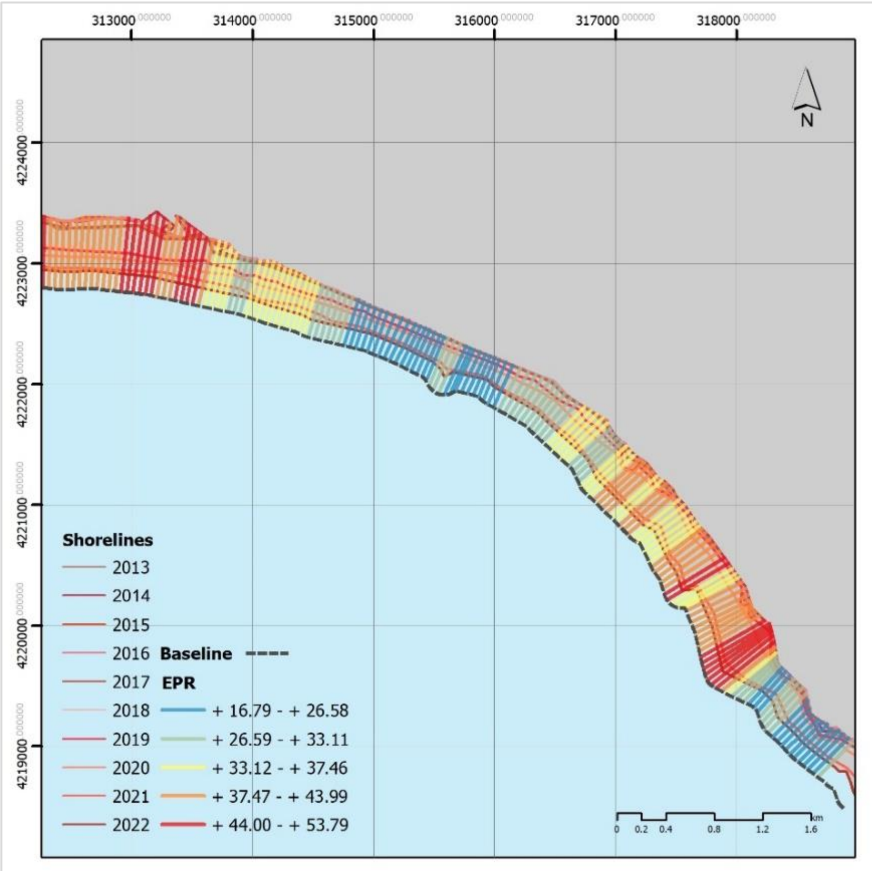

Fig.4 The map of EPR method with geometric interval

In Lake Eğirdir, the accretion values were observed to be well above the +2m/year EPR (End Point Rate) and LRR (Linear Regression Rate) values, which means very high accretion (Fig.4 and Fig.5). In addition, it is seen that the change is more in the north of the shoreline.

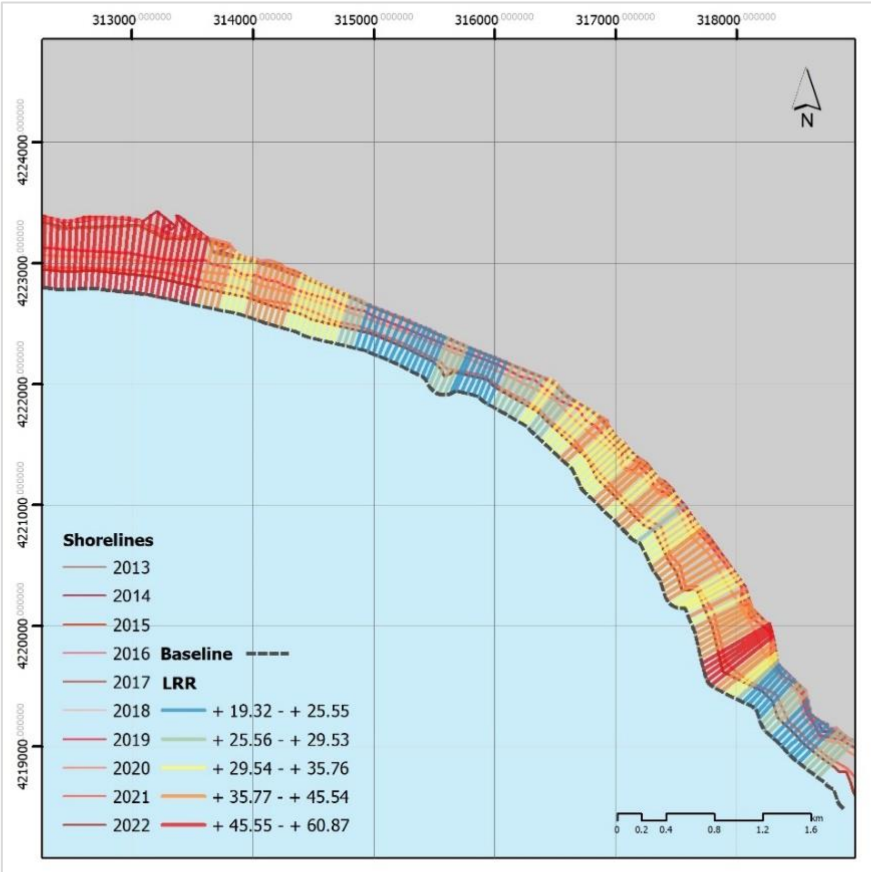

Fig.5 The map of LRR method with geometric interval

EPR and LRR data are graphically shown in Fig.6 According to this, transect ID 149 had the highest LRR (60.87) and transect ID 9 had the lowest LRR (19,32). Transect ID 26 had the highest EPR (53.79) and transect ID 6 had the lowest EPR (16,79).

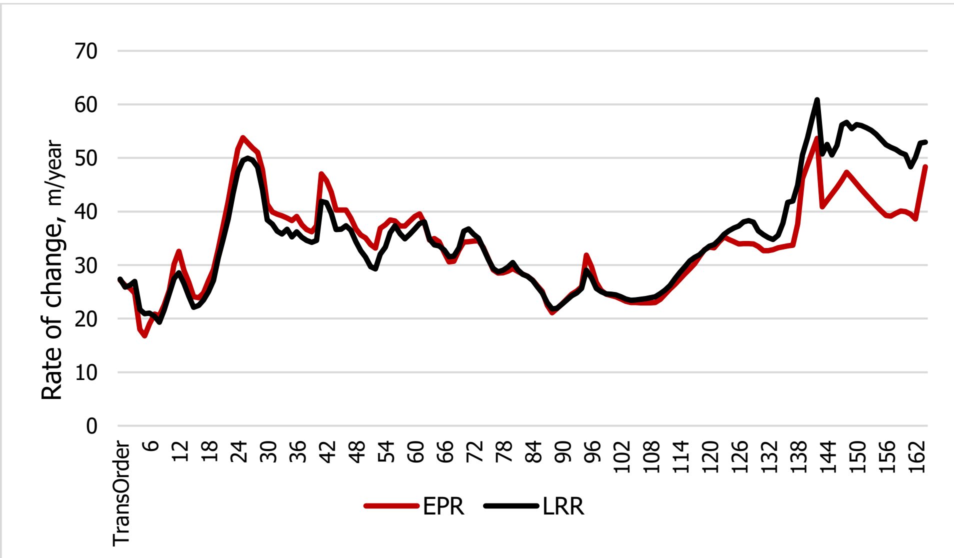

Fig.6 Shoreline trends of the Eğirdir Lake with EPR and LRR value

As a result of the study, it was revealed that there was a great change rate from 2013 to 2022 in the 82 km shoreline determined as the study area. In summary, shoreline change rates in Lake Eğirdir are much higher than the shoreline erosion and accretion scale (Tab.1) stated by the experts. This is an indication that a great change is taking place in the lake. The fact that high values at this level are unlikely to occur only with anthropogenic effects necessitates the examination of the effect of climate change on the lake and a holistic basin assessment.

4. The Implications of climate change on Eğirdir Lake

Researchers state that global climate change is one of the most important threats to lake ecosystems. This change in average weather patterns can cause changes in lake surface conditions such as ice cover, surface temperature, evaporation, and water level. The decrease in the ice cover and the increase in the lake surface temperature during the winter months change the lake mixing regimes and accelerate the lake evaporation. When not offset by increased average precipitation or inflow, higher evaporation rates result in lower lake levels and surface water. Researchers state that these spatial and temporal changes will continue for a long time and in some cases will continue at an accelerated rate (Woolvay et al., 2020).

The variability in the storage of water in lakes, influenced by climate, stems from alterations in the availability of water sources within the lake's surrounding watershed. This variability arises from a delicate balance involving precipitation, evaporation, and fluctuations in terrestrial water storage. (Watras et al., 2014). As air temperatures begin to increase faster than seasonal values, the lake's ice cover will likely decrease, and the lake's surface water temperature will increase. The warming of the surface waters will cause the lake ice to disappear and the evaporation process to start earlier (Woolvay et al., 2020). The amount of water stored in certain lakes may increase, decrease, or not experience significant cumulative changes in a warming climate (Notaro et al., 2015; Pekel et al., 2016; Rodell et al., 2018; Busker et al., 2019).

The attribution of water storage change in lakes to climate change is facilitated by the fact that changes occur consistently in many lakes across large geographic regions (Watras et al., 2014), and other anthropogenic hydrological impacts are calculated and combined. In addition to all these, as it is known, besides global climate change, other human effects can also be effective in shoreline change. The true magnitude of hydrological changes that can certainly be attributed to climate change remains unclear, given the main impact of human dewatering in terms of the global hydrological cycle (Hegerl et al., 2015). Nevertheless, these increases can be attributed to climate change, as they are corroborated by years of ground survey data (Ma, et al, 2010) and recent observations from the Gravity Recovery and Climate Experiment (GRACE) satellite mission (Rodell et al., 2018; Wang et al., 2018), and because there are very little irrigated agriculture operations or water diversions that could confound the trend (Rodell et al., 2018; Woolvay et al., 2020). Therefore, research and projects focus on reducing and adapting to climate impacts (Balletto et al., 2022).

In this context, considering the number of lakes that have dried up recently in Turkey, it is possible that climate change influences this. It is stated that nearly seventy lakes have dried up in the last sixty years in Turkey by researchers (Hürriyet, 2020). In addition, Eğirdir is in the Lake's region of Turkey, and research on lakes in this area highlights that there are significant reductions in the water mass of the lakes. In their study in the Burdur basin located in the Lakes Region, Taş and Akpınar (2021) determined that the lake waters in Burdur Lake, Karataş Lake, Acı Lake, Sıralı Lake, and Ak Lake have been withdrawn largely in the last 36 years and Ak Lake in the basin has completely dried up in 2021. In the study of Dönmez (2018) on Akşehir Lake, which is in the Lake's region, the air temperature being higher than the average temperature after March in 2006, 2007, and 2008 is associated with the complete drying of Akşehir Lake in 2008.

As a result of this study, it was determined that the accretion that occurred in the examined 10-year period (between 2013-2022) was very high. It can be observed that this change has increased remarkably especially in recent years. This situation is interpreted by the author as the possible impact of climate change has become apparent in recent years. Intensive use of the lake and global climate changes have brought about various changes in the water level. The effects of climate change, such as rising temperatures and changing precipitation patterns, have direct implications for lake dynamics. These changes can directly impact the rate of shoreline accretion, leading to notable alterations in the lake's boundary. By amplifying the natural processes responsible for shoreline accretion, climate change exacerbates the phenomenon, resulting in an accelerated rate of change. If preventive measures are not taken, it is estimated that the lake level will decrease by 24% after 100 years (Keskin et al., 2015). Therefore, interactions between climate and other human-related stressors affecting Lake Eğirdir lead to unnatural changes in the Lake Eğirdir shoreline, further complicating the development of climate-resilient and effective management strategies.

5. Conclusion

In this study, the 82 km shoreline to the east of Lake Eğirdir was investigated by DSAS. As a result of the investigations, it is seen that there is a large amount of accretion on the shoreline. As a result of the comprehensive study conducted by Aksoy and others in Turkey's lake region in 2019, similar high accretion was observed in the area. This research and other studies reveal that a holistic watershed management process should be developed for the protection of biological diversity in the lake and the sustainability of the lake. The protection status, approved in 2012, includes some measures and regulations for the preservation of the lake and its surrounding ecosystem. However, this study's results indicate that large-scale accretion events along the lake's shore have caused significant changes in the lake's boundaries.

These findings demonstrate that, despite the existing conservation measures, Lake Eğirdir is under the influence of climate change. Climate change can accelerate natural processes at the lake's boundaries, affecting shoreline changes, which can have significant consequences for the lake ecosystem. In particular, increased surface temperatures and changing precipitation patterns due to climate change can directly impact changes in the lake level and the rate of shoreline accretion. Approaches such as examining these effects and the sensitivity of the lake are important in the adaptation process to climate change (Beltramino et al., 2022). As a result, the protection status of Lake Eğirdir should be considered to enhance resilience against ecological threats brought about by climate change and to develop more effective strategies for sustainable lake management. Also, research about Eğirdir frequently focuses on the anthropogenic effects of the lake (Şener et al., 2023). According to Aksoy et al. (2019), the problems and disruptions in the agricultural policies implemented in Lake Eğirdir can be accurately determined by the temporal change analysis.

These determinations can be used as inputs to the planning processes in agricultural activities. The right working decision mechanism is very important for the protection and sustainability of the ecosystem. In this context, since this study is the first to examine the temporal change on the lake shore of Eğirdir using DSAS, it both provides important literature for taking precautions against climate change and provides temporal data to examine the effects of human activities on Lake Eğirdir. As a result, the data showing the drying up of the lake in the lakes region of Turkey, where Lake Eğirdir is located, and the dense accretion on the lake shoreline obtained as a result of this study, reveal the effects of climate change.

It is important that decision-makers of the lakes and related resources consider the potential for climate change. This can be done by analyzing the potential vulnerability of Lakes to climate change with DSAS. The DSAS tool used in this study can be employed to understand changes in water bodies and water levels and to assess the sustainability of water resources.

In this context, it can be used to monitor coastal or shoreline erosion, develop shoreline protection strategies, and manage shoreline areas. Such studies address topics like safeguarding shoreline infrastructure, evaluating erosion risks, and ensuring the sustainability of shorelines (Mutagin, 2017; Himmelstoss et al., 2018; Nassar et al., 2019). These studies form a part of the need for integrated and adequate tools in both the analysis and design phases to consider the parameters and issues characterizing shoreline area planning (Chieffallo et al., 2022). Thus, managers can determine what anticipatory action should be taken. In this case, understanding potential impacts will help decision-makers make sensible planning decisions to minimize the potential effects of climate change on the lakes.

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Image Sources

Fig.1 to 6: Author's elaboration.

Table Sources

Tab.1: Author's elaboration.

Author's profile

Gizem Dinç

Gizem Dinç completed her M.Sc. degree at Ankara University, Department of Landscape Architecture in 2017. After, she started her career as a research assistant at Süleyman Demirel University, Turkey. In 2021, she did an academic internship at the Federico II University of Naples, Italy. She completed her Ph.D. degree at Süleyman Demirel University, Department of Landscape Architecture in 2002 and continues to work in this department. Her research interests are landscape planning and design, land use/land cover, urban design, walkability, and public spaces.