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Temporal Dynamics of Lake Burdur's Water Surface Area: A Two-Decade Remote Sensing Analysis and Future Forecasts

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Abstract

Factors such as global warming, climate change, increasing population, and industrialization cause spatial and temporal changes in surface water resources. Lake Burdur, which is located in Turkey's Lakes Region and has a tectonic origin with a closed basin characteristic, is one of the significant water resources affected by these changes. The aim of this study is to analyze the change in the surface water area of Lake Burdur between 2003 and 2023 and to provide data that will contribute to the sustainable management of the lake by making predictions for the future. In this context, the Normalized Difference Water Index (NDWI) and the Automated Water Extraction Index for shaded areas ($AWEI_{sh}$) were applied to Landsat 5 and Landsat 8 satellite images. In order to increase spatial accuracy, short-term supporting analyses were also carried out using Sentinel-2 images. Based on the analysis results obtained with both methods, linear regression models were created; surface water area predictions for the years 2028 and 2033 were made, and the model accuracy was also tested. According to the NDWI method, the surface water area loss for the 2003–2023 period was calculated as 22.82%, and it is projected to reach 34.6% by 2033. According to the $AWEI_{sh}$ method, the water loss for the same period was calculated as 22.41%, and the estimate for 2033 was determined as 33.8%. The short-term analysis results based on Sentinel-2 data showed similarity with the Landsat data. The consistent results obtained with images and indices of different resolutions increase the reliability of the analyses; furthermore, they demonstrate that remote sensing–based approaches are an effective tool for predicting water loss in Lake Burdur.

1. Introduction

Water resources are one of the building blocks of the natural ecosystem and are of vital importance for all living beings [1]. The existence of water resources is directly related to the welfare of human societies [2].

Climate changes, increasing greenhouse gas emissions, and global warming lead to reductions and changes in water resources [3]. This reduction in water resources reveals the necessity of effective monitoring and management of surface water resources [4]. It is possible to rapidly and comprehensively analyze the changes occurring in surface water resources using remote sensing technology [5]. Today, with the advancement of remote sensing technologies, satellite platforms such as MODIS, Landsat, and Sentinel provide extensive data sources for the identification of surface water bodies and the monitoring of their changes [6-7]. Google Earth Engine (GEE), one of the cloud-based platforms, hosts a large number of publicly available geospatial datasets and offers the capability to process these data [8].

Many studies have demonstrated the effectiveness of remote sensing (RS) and spectral indices in monitoring surface water changes. McFeeters (1996) developed the Normalized Difference Water Index (NDWI); Xu (2006) proposed the Modified NDWI (MNDWI) to improve detection sensitivity in urban areas [9-10]. Feyisa et al. (2014) developed the Automated Water Extraction Index (AWEI) to increase classification accuracy in shaded or low-reflectance areas [11]. Such indices are widely used in satellite-based water detection studies. Sabuncu (2020) analyzed the surface water area change of Lake Burdur between 1986 and 2019 using Landsat 5 and Landsat 8 satellite images. The analyses conducted using the Modified NDWI (MNDWI) revealed that the lake area decreased from 206 km^2 to 125 km^2 [12]. Khalid et al. (2021) conducted a study on the evaluation of spectral indices for water body extraction in the western Tibetan Plateau [13]. In a similar study, Kılınçarslan et al. (2024) examined land cover changes in Lake Uluabat, a Ramsar site, using Landsat satellite images, and determined a 15.8% decrease in lake area over a 20-year period [14]. El-Bouhali et al. (2024) investigated the changes in water surface area of the Middle Atlas-Morocco lakes using Landsat TM, OLI, and OLI-2 satellite images [15]. Zhang et al. (2025) evaluated the performance of 15 different water detection indices using Sentinel-2 satellite images. The study contributed to determining the most suitable indices for water surface detection by comparing the effectiveness of the indices under different environmental conditions [16].

Lake Burdur, located in Turkey's Lakes Region, is among the largest and deepest lakes in the country [17]. Since 1987, Lake Burdur has been experiencing significant water loss. This loss has caused spatial and temporal changes in the lake [18]. The aim of this study is to analyze the changes in the water surface area of Lake Burdur using Landsat and Sentinel satellite images on the Google Earth Engine (GEE) platform, and to make predictions about the future of the lake based on the obtained data. Within the scope of the analysis, spectral indices including the Normalized Difference Water Index (NDWI) and the Automated Water Extraction Index for shaded areas ($AWEI_{sh}$) were used to detect and visualize changes in the water surface area. In addition, a linear regression model was used to investigate possible changes in water surface area for the years 2028 and 2033. With all these analyses, it is aimed to obtain the necessary data to contribute to the sustainable management of Lake Burdur.

2. Method

2.1. Study Area

Lake Burdur, located in southwestern Turkey within the boundaries of Burdur and Isparta provinces, is a tectonically formed closed basin (Fig. 1). The lake, which reaches a surface area of approximately 140 km^2 and a depth of up to 110 meters, is one of the largest and deepest lakes in Turkey. Its water is saline and highly alkaline. Recognized as a Ramsar Site, the lake is an important habitat for various bird species [17,19]. Situated in a transition zone between the Mediterranean and continental climates, Lake Burdur exhibited relatively stable water levels until around 20 years ago. However, since 1987, the lake has experienced a continuous decline in water levels [18]. This significant and alarming decrease is attributed to a combination of climatic and anthropogenic factors [20].

2.2. Data

In this study, Landsat satellite images with a spatial resolution of 30 meters and Sentinel-2 satellite images with a spatial resolution of 10 meters were used. Landsat 5 images from the years 2003 and 2008, and Landsat 8 images from the years 2013, 2018, and 2023 were utilized. Due to the SLC (Scan Line Corrector) failure in the Landsat 7 sensor, Landsat 5 satellite images were preferred for the years 2003 and 2008. In addition, a total of four Sentinel-2 satellite images from the years 2017, 2019, 2021, and 2023 were selected in the analyses.

To ensure seasonal consistency and to keep the cloud ratio low, care was taken to ensure that all nine images were from the month of September. These images, with less than 10% cloud cover, were obtained through the USGS Earth Explorer and Copernicus Browser platforms and analyzed in the Google Earth Engine (GEE) environment.

Figure 1. Study Area: Lake Burdur, Türkiye

Collection 2 Level-2 products were used for the Landsat images. These products represent the most up-to-date and processed versions of Landsat data, including atmospheric corrections, radiometric calibrations, and georeferencing adjustments. The characteristics of the images used in the study are presented in Table 1.

Table 1. Details of the satellite imagery utilized in the study.

Image date	Satellite	Dataset	Cloud cover
2003-09-23	Landsat 5	Collection 2 Level 2	0.00
2008-09-11	Landsat 5	Collection 2 Level 2	0.00
2013-09-25	Landsat 8	Collection 2 Level 2	0.04
2018-09-23	Landsat 8	Collection 2 Level 2	0.05
2023-09-21	Landsat 8	Collection 2 Level 2	0.07
2024-09-07	Landsat 8	Collection 2 Level 2	0.06
2017-09-24	Sentinel-2	L2A	0.06
2019-09-29	Sentinel-2	L2A	0.06
2021-09-28	Sentinel-2	L2A	0.06
2023-09-23	Sentinel-2	L2A	0.08
2024-09-07	Sentinel-2	L2A	0.05

2.3. Spectral Indices

2.3.1. Normalized Difference Water Index (NDWI)

To determine the surface water characteristics of Lake Burdur, the Normalized Difference Water Index (NDWI) method was initially applied. This index is designed to enhance the visibility of water bodies by minimizing the influence of non-water features such as vegetation and soil in satellite images. NDWI is calculated using green and near-infrared (NIR) bands, producing positive values for water features and negative values for non-water elements. The NDWI values range between -1 and +1 [9]. In this study, NDWI was applied to Landsat 7, Landsat 8 and Sentinel-2 imagery using the Google Earth Engine platform. The formula used is presented in Equation 1. Based on the resulting index values, a threshold value of 0 was selected to separate water and non-water areas and to create a water mask in order to determine the surface water area of Lake Burdur by year. This method enabled the calculation of the lake's surface water area for each selected year and contributed to the analysis of temporal changes.

$$NDWI = \frac{green - NIR}{green + NIR} \quad (1)$$

2.3.2. Automated Water Extraction Index (AWEI)

To ensure accurate and efficient identification of water bodies in satellite imagery, the shadow version of the Automated Water Extraction Index ($AWEI_{sh}$) was utilized. This index was developed to improve accuracy in surface water mapping, environmental monitoring, and change detection studies by minimizing the influence of dark surfaces such as shadows cast by buildings, mountains, dense vegetation, or clouds, which commonly cause misclassification. $AWEI_{sh}$ enhances the presence of water features while reducing the prominence of non-water elements through the use of selected fixed coefficients applied to visible, near-infrared (NIR) and shortwave infrared (SWIR) bands [11]. In this study, the $AWEI_{sh}$ index was applied to Landsat 5, Landsat 8 and Sentinel-2 satellite imagery using the Google Earth Engine platform. The formula used is presented in Equation 2. Based on the resulting values, a threshold was applied to generate a water mask in order to calculate the surface water area. This approach provided a more reliable detection of water bodies, especially in areas with potential shadow conditions.

$$AWEIsh = blue + 2.5 \times green - 1.5 \times (NIR + SWIR1) - 0.25 \times SWIR2 \quad (2)$$

3. Results

In this study, analyses were conducted on Landsat and Sentinel satellite images from different years using JavaScript code on the Google Earth Engine platform to identify surface water bodies. NDWI (Normalized Difference Water Index) and $AWEI_{sh}$ (Automated Water Extraction Index) were applied to Landsat 5 images from September 2003 and 2008, Landsat 8 images from September 2013,2018 and 2023, as well as Sentinel-2 images from September 2017, 2019, 2021 and 2023. The results obtained from applying the NDWI index to the Landsat imagery are presented in Fig. 2, while those derived from Sentinel-2 imagery are shown in Fig. 3. The outputs of the $AWEI_{sh}$ index applied to Landsat and Sentinel images are presented in Fig. 4 and Fig. 5, respectively.

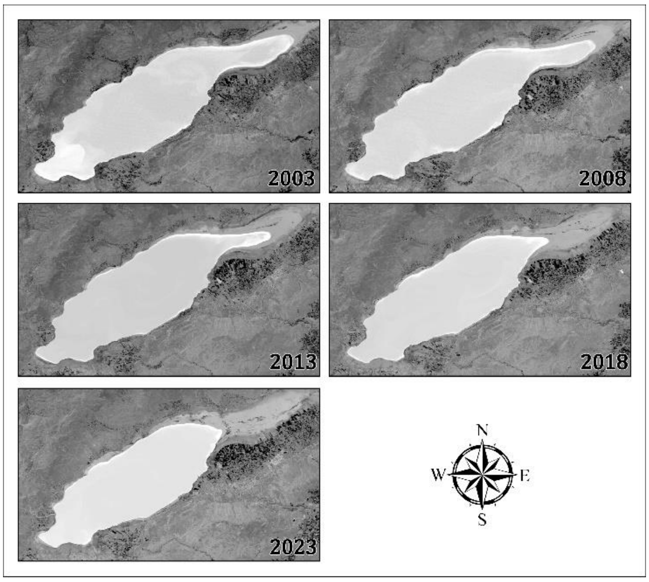

Figure 2. Landsat satellite images processed with NDWI by year.

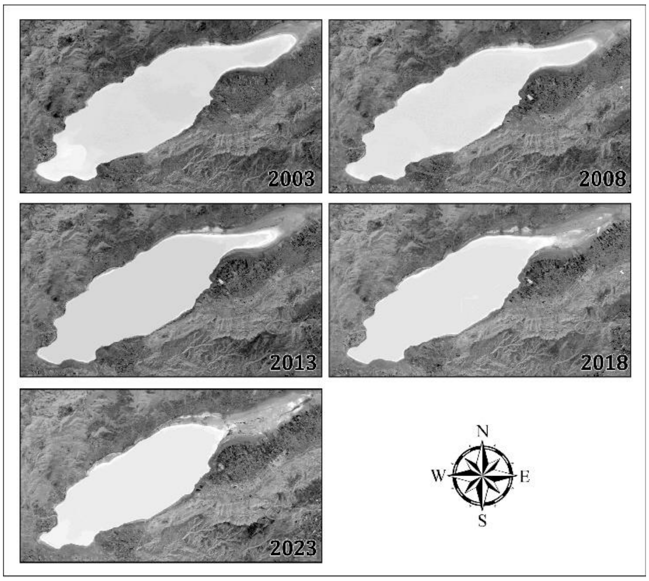

Figure 3. Landsat satellite images processed with $AWEI_{sh}$ by year.

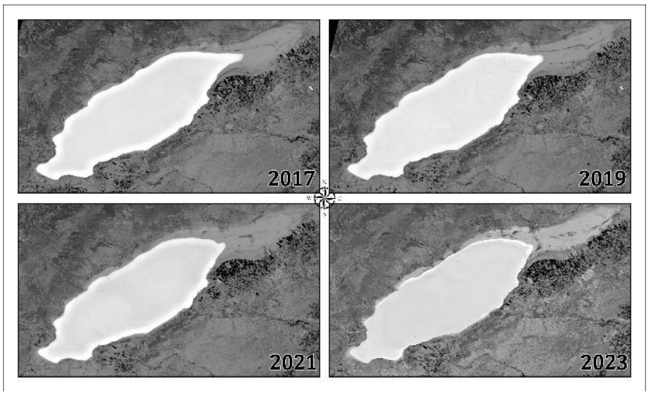

Figure 4. Sentinel satellite images processed with NDWI by year.

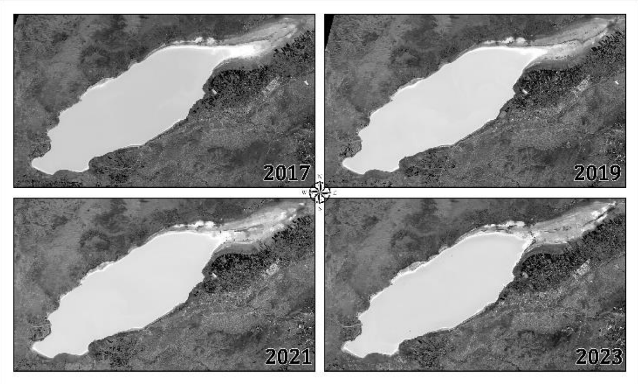

Figure 5. Sentinel satellite images processed with AWEI$_{sh}$ by year.

The surface water area of Lake Burdur, calculated using the NDWI method based on Landsat satellite images, was determined as 153.381 km^2 in 2003, while this value was calculated as 118.374 km^2 in 2023. Similarly, calculations made using Landsat satellite images and the AWEI$_{sh}$ method showed that the surface water area was 156.623 km^2 in 2003 and 121.52 km^2 in 2023. In calculations based on Sentinel satellite images, the surface water area for 2023 was determined as 119.821 km^2 using the NDWI method and 126.997 km^2 using the AWEI$_{sh}$ method. The graph created using the surface water area values calculated with the NDWI and AWEI$_{sh}$ methods applied to Landsat satellite images for specified years is presented in Fig. 6. The graph created using the surface water area values calculated with the mentioned methods based on Sentinel satellite images is presented in Fig. 7. The obtained findings revealed that there are differences between the surface water area values calculated for the same years using the NDWI and AWEI$_{sh}$ methods. In line with these differences, when the annual percentage difference values calculated using the data obtained from Landsat satellite images are examined, the lowest percentage difference is 2.09% for the year 2003, while the highest percentage difference is 3.01% for the year 2013. The surface water area values calculated with these two methods and the annual percentage difference values for the years based on Landsat images are presented in Table 2 while the values calculated using Sentinel images are presented in Table 3.

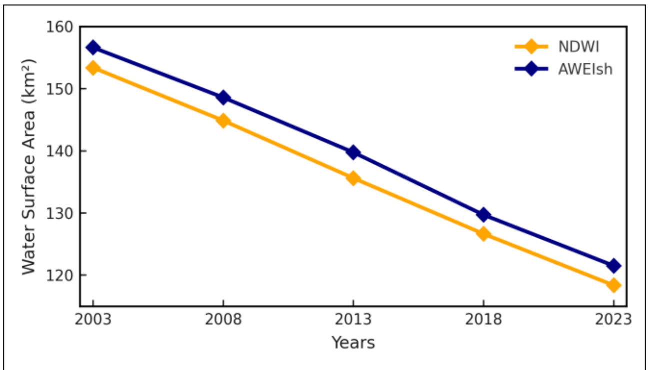

Figure 6. Temporal change in the surface water area of Lake Burdur (2003–2023) (Landsat imagery).

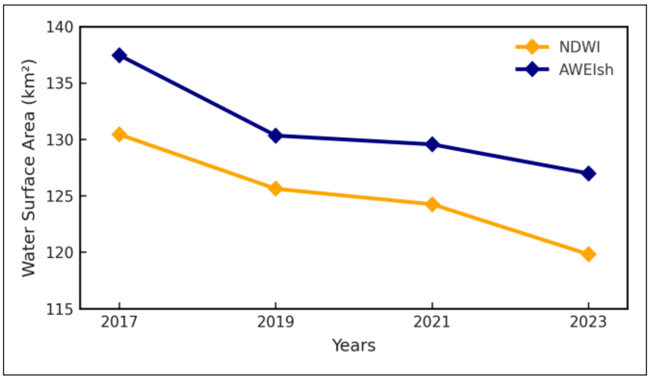

Figure 7. Temporal change in the surface water area of Lake Burdur (2017–2023) (Sentinel imagery).

Table 2. Surface water areas of Lake Burdur calculated using the NDWI and AWEI$_{sh}$ indices, and the percentage differences between the two methods (Landsat imagery).

Image year	With NDWI (km^2)	With AWEI$_{sh}$ (km^2)	Percentage difference
2003	153.381	156.623	2.09%
2008	144.869	148.589	2.54%
2013	135.616	139.760	3.01%
2018	126.650	129.710	2.39%
2023	118.374	121.520	2.62%

Table 3. Surface water areas of Lake Burdur calculated using the NDWI and AWEI$_{sh}$ indices, and the percentage differences between the two methods (Sentinel imagery).

Image year	With NDWI (km^2)	With AWEI$_{sh}$ (km^2)	Percentage difference
2017	130.451	137.479	5.25%
2019	125.635	130.349	3.68%
2021	124.262	129.573	4.18%
2023	119.821	126.997	5.81%

Based on the surface water area change values of Lake Burdur for the specified years, linear regression equations were obtained for both methods (NDWI and AWEI$_{sh}$) using data derived from Landsat satellite images. Using Equation 3 for the AWEI$_{sh}$ method and Equation 4 for the NDWI method, the estimated surface water area values for the years 2028 and 2033 were calculated. According to the projections made using the NDWI method, the estimated surface water area of Lake Burdur was calculated as 109.188 km^2 for the year 2028 and 100.365 km^2 for the year 2033. In the estimations made using the AWEI$_{sh}$ method, these values were calculated as 112.512 km^2 for 2028 and 103.604 km^2 for 2033. The results of the estimated values are presented in Table 4. Additionally, based on the data obtained from Sentinel satellite images, Equation 5 was derived for the NDWI method and Equation 6 for the AWEIsh method; through these equations, the estimated surface water area values for the years 2028 and 2033 were obtained. According to the estimations made using these methods, the surface water area was calculated as 111.630 km^2 in 2028 and 103.314 km^2 in 2033 for the NDWI method; and as 118.189 km^2 in 2028 and 110.134 km^2 in 2033 for the $AWEI_{sh}$ method. These values are presented in Table 5.

$$y = -1{,}7817x + 3725{,}8 \quad (3)$$

$$y = -1{,}7647x + 3688 \quad (4)$$

$$y = -1.6632x + 3484.6 \quad (5)$$

$$y = -1.6111x + 3385.5 \quad (6)$$

Table 4. Estimated surface water area values for the years 2028 and 2033 (Landsat imagery).

Year	With NDWI (km²)	With $AWEI_{sh}$ (km²)
2028	109.188	112.512
2033	100.365	103.604

Table 5. Estimated surface water area values for the years 2028 and 2033 (Sentinel imagery).

Year	With NDWI (km²)	With $AWEI_{sh}$ (km²)
2028	111.630	118.189
2033	103.314	110.134

Based on current data, the surface water area of Lake Burdur for September 2024 was calculated using Landsat 8 satellite imagery through the NDWI and $AWEI_{sh}$ methods. As a result of this analysis, the surface water area was determined as 116.888 km² using the NDWI method and 117.972 km² using the $AWEI_{sh}$ method. These values were compared with the estimated 2024 surface water area values derived from the linear regression equations obtained from the surface water area data between 2003 and 2023. As a result of this comparison, the accuracy for 2024 was calculated as 99.45% for the NDWI method and 98.59% for the AWEIsh method. These values are presented in Table 6.

A similar analysis was also conducted using Sentinel satellite imagery. In the calculations for 2024, the surface water area was found to be 117.723 km² using the NDWI method and 120.918 km² using the $AWEI_{sh}$ method. These calculated values were compared with the estimated 2024 surface water area values obtained from the linear regression equations derived from Sentinel data, and the accuracy was determined as 99.53% for the NDWI method and 97.02% for the $AWEI_{sh}$ method. The relevant calculation and comparison results are presented in Table 7.

Table 6. Comparison between observed and estimated surface water area of Lake Burdur in 2024 (Landsat imagery).

Used index	2024 calculated surface water area (km²)	2024 estimated surface water area (km²)	Accuracy (%)
NDWI	116.888	116.247	99.45%
AWEIsh	117.972	119.639	98.59%

Table 7. Comparison between observed and estimated surface water area of Lake Burdur in 2024 (Sentinel imagery).

Used index	2024 calculated surface water area (km²)	2024 estimated surface water area (km²)	Accuracy (%)
NDWI	117.723	118.283	99.53%
AWEIsh	120.918	124.634	97.02%

4. Discussion

In this study, the use of 30-meter resolution Landsat images for the month of September between 2003 and 2023, and 10-meter resolution Sentinel-2 images for the same month between 2017 and 2023, provided a significant advantage in improving both temporal and spatial accuracy and made it possible for the analyses to support each other. According to the analyses conducted using both methods, there has been a continuous decrease in the lake's surface water area, and this decrease had reached a significant and severe level by 2023. Due to the limited operational period of the Sentinel-2 satellite, only a shorter time span could be analyzed with this dataset. However, the fact that these short-term analyses are consistent with the Landsat results demonstrates the overall reliability of the analyses, and the similar results obtained using the two widely used water indices, NDWI and AWEIsh, support the consistency between methods.

According to the obtained findings, the $AWEI_{sh}$ method produced higher surface water area values compared to the NDWI method for the same years. This difference can be attributed not only to the differences in the formulations of the two methods, but also to the $AWEI_{sh}$ method's ability to detect surface water more effectively across various land types, even in smaller water bodies. Especially in mountainous, rugged areas; in regions with complex land cover; or under the influence of cloud shadows, NDWI may fail to detect certain water pixels or small water bodies. Nevertheless, both methods revealed the temporal water loss in a similar way, confirming the reliability of remote sensing techniques in long-term hydrological change analyses.

When the calculated surface water area values for 2024 were compared with the estimated values obtained using regression equations, high accuracy rates were achieved for the NDWI and $AWEI_{sh}$ methods using Landsat and Sentinel-2 satellite images with different spatial resolutions. This level of accuracy demonstrates that the linear regression models developed using Landsat data from 2003 to 2023 and Sentinel data from 2017 to 2023 can produce reliable predictions regarding potential future water loss in Lake Burdur and supports the overall reliability of the study. However, while the regression models provide strong predictive performance, it is important to emphasize that they are based on empirical relationships and may not fully capture the influence of dynamic environmental conditions. Factors such as atmospheric variability (e.g., cloud cover, aerosol content), seasonal changes (e.g., snowmelt, vegetation growth), and long-term climatic variability can introduce uncertainty into surface water detection and model predictions. It should be noted that various factors such as atmospheric conditions and land cover may affect the performance of the indices. While the $AWEI_{sh}$ method performs better under more complex image conditions, the NDWI method can produce more effective results in open areas. Therefore, future studies should consider incorporating seasonal and environmental variables directly into the regression modeling process to account for these potential sources of variability and improve model robustness. In future studies, more comprehensive evaluations can be made by including additional parameters such as precipitation, evaporation, temperature, and human impact.

5. Conclusion

In the study presented in this article, the change in the surface water area of Lake Burdur over the 20-year period between 2003 and 2023 was analyzed using 30-meter resolution Landsat satellite imagery and two water indices, NDWI and $AWEI_{sh}$. In addition, future predictions were made based on the obtained data. In order to increase the consistency of the study, the same analysis was also carried out using 10-meter resolution Sentinel-2 satellite imagery for the period between 2017 and 2023. In this context, both methods applied to satellite images with two different spatial resolutions clearly revealed that the decrease in the lake's surface area occurred significantly over time.

According to the results obtained from Landsat imagery, the NDWI-based analysis showed that Lake Burdur lost approximately 22.82% of its surface water area over the 20-year period, and it is estimated that this rate will reach 34.6% by the year 2033. In the AWEIsh-based analysis, the surface water loss during the same period was approximately 22.41%, and this rate is predicted to reach 33.8% by 2033.

Analyses based on Sentinel-2 satellite imagery showed that, according to NDWI results, the lake lost 8.16% of its surface water area between 2017 and 2023, while according to AWEIsh results, this rate was 7.64%. It is projected that this downward trend will continue until 2033, with the surface water loss estimated at 20.77% according to NDWI and 19.90% according to AWEIsh. In general, the AWEIsh method's effectiveness in small water bodies and shadowed areas enabled it to produce higher surface water area values compared to the NDWI method.

As a result of the linear regression analyses, the estimated values for 2024 largely overlapped with the actual calculated values. In analyses based on Landsat data, an accuracy rate of 99.45% was obtained for the NDWI method and 98.59% for the $AWEI_{sh}$ method. In analyses based on Sentinel-2 data, the accuracy rate was 99.53% for the NDWI method and 97.02% for the $AWEI_{sh}$ method. These findings demonstrated the reliability of both the applied methods and the developed prediction models.

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Author contributions

Kemal Can Erdem: Conceptualization, Data curation, Writing-Original draft preparation, Software. **Tolga Bakirman:** Methodology, Investigation, Writing-Reviewing and Editing, Software, Validation. **Bulent Bayram:** Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. UNESCO. (2021). The United Nations world water development report 2021: Valuing water. United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000375724
2. Duran-Encalada, J. A., Paucar-Caceres, A., Bandala, E. R., & Wright, G. H. (2017). The impact of global climate change on water quantity and quality: A system dynamics approach to the US–Mexican transborder region. European Journal of Operational Research, 256(2), 567–581. https://doi.org/10.1016/j.ejor.2016.06.016
3. Ahady, A. B., & Kaplan, G. (2022). Classification comparison of Landsat-8 and Sentinel-2 data in Google Earth Engine, study case of the city of Kabul. International Journal of Engineering and Geosciences, 7(1), 24 – 31. https://doi.org/10.26833/ijeg.860077
4. Kanber, R., Baştuğ, R., Büyüktaş, D., Ünlü, M., & Kapur, B. (2010, January 11–15). Küresel iklim değişikliğinin su kaynakları ve tarımsal sulamaya etkileri. In TMMOB Ziraat Mühendisleri Odası (Ed.), Ziraat Mühendisliği VII. Teknik Kongresi: Bildiriler kitabı (pp. 83–118). Ankara, Turkey.
5. Jiang, H., Feng, M., Zhu, Y., Lu, N., Huang, J., & Xiao, T. (2014). An Automated Method for Extracting Rivers and Lakes from Landsat Imagery. Remote Sensing, 6(6), 5067–5089. https://doi.org/10.3390/rs6065067
6. Tang, H., Lu, S., Ali Baig, M. H., Li, M., Fang, C., & Wang, Y. (2022). Large-Scale Surface Water Mapping Based on Landsat and Sentinel-1 Images. Water, 14(9), 1454. https://doi.org/10.3390/w14091454
7. Yağmur, N., Tanık, A., Tuzcu, A., Musaoğlu N., Erten E., & Bilgilioglu, B. (2020). Opportunities provided by remote sensing data for watershed management: example of Konya Closed Basin. International Journal of Engineering and Geosciences, 5(3), 120 – 129. https://doi.org/10.26833/ijeg.638669
8. Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote Sensing of Environment, 202, 18–27. https://doi.org/10.1016/j.rse.2017.06.031
9. McFEETERS, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. International Journal of

Remote Sensing, 17(7), 1425–1432. https://doi.org/10.1080/01431169608948714

10. Xu, H. (2006). Modification of Normalized Difference Water Index (NDWI) to enhance open water features in remotely sensed imagery. International Journal of Remote Sensing, 27(14), 3025–3033. https://doi.org/10.1080/01431160600589179
11. Feyisa, G. L., Meilby, H., Fensholt, R., & Proud, S. R. (2014). Automated Water Extraction Index: A new technique for surface water mapping using Landsat imagery. Remote Sensing of Environment, 140, 23–35. https://doi.org/10.1016/j.rse.2013.08.029
12. Sabuncu, A. (2020). Burdur Gölü Kıyı Şeridindeki Değişiminin Uzaktan Algılama ile Haritalanması. Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 20(4), 623–633. https://doi.org/10.35414/akufemubid.711653
13. Khalid, H. W., Khalil, R. M. Z., & Qureshi, M. A. (2021). Evaluating spectral indices for water bodies extraction in western Tibetan Plateau. The Egyptian Journal of Remote Sensing and Space Science, 24(3), 619–634. https://doi.org/10.1016/j.ejrs.2021.09.003
14. Kılınçarslan, E., Gencal, B., & Taş, İ. (2024). Assessing Two Decades of Land Use/Land Cover Changes in the Uluabat Lake Ramsar Site using Multi-Temporal Satellite Imagery. European Journal of Forest Engineering, 10(2), 100–111. https://doi.org/10.33904/ejfe.1318353
15. El-Bouhali, A., Amyay, M., & El Ouazanı Ech- Chahdi, K. (2024). Changes in water surface area of the Middle Atlas-Morocco lakes: A response to climate and human effects. International Journal of Engineering and Geosciences, 9(2), 221 – 232. https://doi.org/10.26833/ijeg.1391957
16. Zhao, C., Wei, H., Feyisa, G. L., de Castro Tayer, T., Ma, G., Wu, H., & Pan, Y. (2025). Evaluating spectral indices for water extraction: Limitations and contextual usage recommendations. International Journal of Applied Earth Observation and Geoinformation, 139, 104510. https://doi.org/10.1016/j.jag.2025.104510
17. Davraz, A., Sener, E., & Sener, S. (2019). Evaluation of climate and human effects on the hydrology and water quality of Lake Burdur, Turkey. Journal of African Earth Sciences, 158, 103569. https://doi.org/10.1016/j.jafrearsci.2019.103569
18. Ataol, M. (2010). Burdur Gölü'nde Seviye Değişimleri. Coğrafi Bilimler Dergisi, 8(1), 77–92. https://doi.org/10.1501/Cogbil_0000000105
19. Kaya, L. G., Yücedağ, C., & Duruşkan, Ö. (2015). Burdur Gölü havzasının çevresel açıdan irdelenmesi. Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 6(1), 6–10. https://doi.org/10.29048/makufebed.206586
20. Abujayyab, S. K. M., Almotairi, K. H., Alswaitti, M., Amr, S. S. A., Alkarkhi, A. F. M., Taşoğlu, E., & Hussein, A. M. (2021). Effects of Meteorological Parameters on Surface Water Loss in Lake Burdur, Turkey over 34 Years Landsat Google Earth Engine Time-Series. Land, 10(12), 1301. https://doi.org/10.3390/land10121301