Intercontinental Geoinformation Days

igd.mersin.edu.tr

Determination of Karina Lagoon surface area water temperature changes using remote sensing methods

Elif Akyel[*1], Özşen Çorumluoğlu [1]

[1]*Izmir Kâtip Çelebi University, Faculty of Engineering and Architecture, Department of Geomatics, İzmir, Turkey*

Keywords
Karina Lagoon
AWEI
Water Temperature
Thermal Band
Remote Sensing

ABSTRACT

Evaporation, inability to feed from land, and especially in areas where the lagoon joins the sea, deposits that form over time form embankments, such as lake level changes over time, causes a change in lake level. Remote sensing methods, which provide important advantages in the detection of this change, also provide information about the parameters affecting the lake ecosystem. One of the parameters affecting the lake ecosystem is the surface water temperature. In the study, the Karina Lagoon located in Aydın was examined. The aim of the study is to determine the temperature changes in the lake surface water between 1985 and 2020 using Landsat satellite images. Firstly, Automatic Water Extraction Index (AWEI) was applied to Landsat satellite images in order to determine the lake surface area. Firstly, the Automatic Water Extraction Index (AWEI) was applied to the Landsat satellite images to determine the lake surface area. Thus, the spatial change in the lagoon was determined as a decrease of 6.85%. The AWEI method worked with a minimum accuracy of 91%. Then, the lake surface temperatures were determined by using the thermal bands of the satellite images. Maximum measured water temperature of 30.42 ^{0}C, minimum measured 17.93 ^{0}C.

1. Introduction

One of the places that attract attention in terms of tourism and attract the most attention is the natural areas, especially national parks, which are under protection (Bekdemir et al., 2010). Dilek Peninsula Büyük Menderes Delta National Park is located at the last point where Dilek Mountain reaches the Aegean Sea within the borders of Aydın province and has an area of 27,675 hectares. 10,985 hectares of this area belong to Dilek Peninsula, which was declared a National Park on 19.05.1966, and 16,690 hectares to Büyük Menderes Delta, which was declared a National Park in 1994. Dilek Peninsula has a great importance in terms of containing elements of Mediterranean Flora Region and European Siberia Flora Region. Büyük Menderes Delta contained in Biological Diversity, endangered species, endemic species and the International Convention on wetlands (Ramsar), the European Convention for the protection of wildlife and habitats (Bern), the convention on Biological Diversity (Rio) and the convention on the protection of the Mediterranean Sea against pollution (Barcelona) is intended as within the scope of a protected zone. Büyük Menderes Delta, which is of international importance, has the feature of "Class A Wetland". Due to its diversity, Dilek Peninsula and Buyuk Menderes Delta National Park have been declared as a 'Flora Biogenetic Reserve Area' by the Council of Europe and have been protected.

As a result of the displacement of the river in the Büyük Menderes Delta and the separation of the alluvium it carries from the sea by blocking the way of the old bays and bays, many lagoons large and small have been formed in the delta. Karina Lagoon, one of the lagoons formed, is located within the borders of Dilek Peninsula Büyük Menderes National Park.

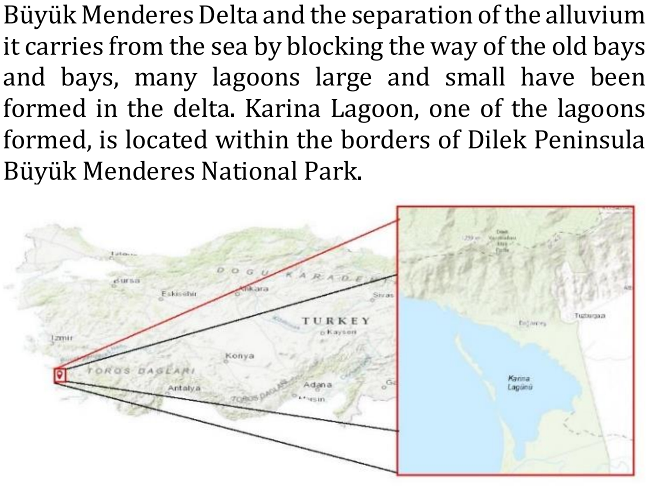

Figure 1. Study Area

* **Corresponding Author**

*(elif.akyel@ikc.edu.tr) ORCID ID 0000-0002-9355-7478
(ozsen.corumluoglu@ikcu.edu.tr) ORCID ID 0000-0002-7876-6589

Cite this study

Akyel E & Çorumluoğlu Ö (2021). Determination of Karina Lagoon surface water temperature change using remote sensing methods. 3rd Intercontinental Geoinformation Days (IGD), 113-116, Mersin, Turkey

Karina Lagoon, the location of which is shown on the map with Fig. 1, had an area of 2794.14 hectares in 1985, while it reached an area of 2602.71 hectares in 2020. However, the lagoon, which reached its widest limits in 2005 and reached its smallest limits in 2020, is an indication that there is no linear increase or decrease in the lake. In addition to this spatial change, when the changes in lake water temperatures are examined, it has been determined that the maximum temperature was 30.42^{0}C in 2000 and the minimum temperature was 17.93^{0}C in 2010.

2. Method

In the study, the Karina Lagoon water surface area change was examined using satellite images In this context, satellite images obtained from Landsat 5 TM and Landsat 8 OLI-TIRS sensors were used. Landsat satellite data has important advantages in monitoring and evaluating long-term land changes (Gülci et al.,2019).

Landsat 5 TM data from 1985-2011 and Landsat 8 OLI-TIRS data from 2013-2020 were used as image data in the study. Satellite images are available free of charge from the USGS (United States Geological Survey). While selecting satellite images, due to the fact that the weather conditions are approximately the same in the same season, it was paid attention to the images obtained in the same months while selecting images from different years. In order to minimize the effect of factors such as clouds and atmospheric humidity that directly affect the image quality, June was preferred when the cloudiness rate was low (Özcalik et al., 2020). The accuracy of the results obtained was tried to be improved by selecting images with 10% or less cloudiness.

2.1. Image preprocessing

Electromagnetic radiation detected by various sensors, gases moving towards the sensing sensor from the earth's surface, are exposed to atmospheric (scattering, absorption by aerosols, etc.) effects. Radiometric distortions occur due to the changes in the light falling on the images, the geometry of the view, atmospheric conditions and the response time of the sensor Atmospheric and radiometric corrections should be applied on satellite images in order to minimize the resulting system errors and to eliminate the distortions caused by atmospheric particles. (Bektaş et al.,2008 ; SONG et al., 2001; Liang, 2004). In order to achieve optimum accuracy in the analyzes in the studies on the detection of spatial changes that occur over time, preprocessing procedures should be applied to the images.

The formula given in Equation (1) and Equation (2) was applied to the obtained images. Then the classification process was carried out.

$$\rho\lambda = \pi * (((L_{MAX\lambda} - L_{MIN\lambda}) / (Q_{CALMAX} - Q_{CALMIN})) * (Q_{CAL} - Q_{CALMIN}) + L_{MIN\lambda}) - (((L_{MAX\lambda} - L_{MIN\lambda}) / (Q_{CALMAX} - Q_{CALMIN})) * (x - 1) + L_{MIN\lambda})) * d_2 / ESUN_\lambda * \cos\theta_S \quad (1)$$

$$\rho\lambda = (((M_\rho * Q_{CAL}) + A_\rho) - ((M_\rho * x) + A_\rho)) / (\cos(35.20373 * \pi / 180)) \quad (2)$$

2.2. Band ratio methods

A new image is obtained by applying arithmetic operations to bands representing different spectral ranges. It is possible to highlight the attribute of an object over the resulting image.

In this study, the characteristics of each target between different spectral bands were analyzed using the AWEI band ratio technique. Based on the analysis, the land is separated from the water surface by finding the differences between the water and other targets (Yu et al., 1998; Xu 2002).

2.2.1. AWEI

The AWEI band ratio index was developed to increase the contrast between water and other dark surfaces. The primary goal of the AWEI formulation is to maximize the separability of water and non-water pixels by applying band difference, splice and different coefficients. (Feyisa et al., 2014). The AWEI index can be calculated using the formula given in Equation (3).

$$AWEI = 4*(\rho green - \rho SWIR1) - ((0.25*\rho NIR) + (2.75x\rho SWIR2)) \quad (3)$$ (Feyisa et al.,2014;Şener,2016)

2.3. Determination of lake surface water temperatures using thermal band

In this study, surface water temperature values were determined using the thermal bands of Landsat 5 and Landsat 8 satellites. In order to determine the surface temperature values from the Landsat satellite image, the images were downloaded from the USGS web page with their metadata in GeoTIFF format. First, the digital number (DN) in the image was converted to spectral radiance values using formula (4) and formula (5).

Landsat 5 Digital number to radiance conversion:

$$L\lambda = (Lmax\lambda - Lmin\lambda)\ (Qcalmax - Qcalmin) * ((Qcal - Qcalmin) + (Lmin\lambda)) \quad (4)$$

Landsat 8 Digital Number to Radiance conversion:

$$L\lambda = ML*QCAL+AL \quad (5)$$

Where :
$L\lambda$: spectral radiance values (Watts/(m2*sr*µm),
$Lmin\lambda$: Spectral radiance values scaled to $Qcalmin$,
$Lmax\lambda$: Spectral radiance values scaled to $Qcalmax$,
$Qcal$: Calibrated pixel values
$Qcalmin$: Calibrated minimum pixel values
$Qcalmax$: Calibrated maximum pixel values

K1 and K2 Thermal Conversion Constants given by the USGS (2013) are used during the process (6) of converting radiance values obtained from Landsat satellite images to luminosity temperatures (Table 1).

$$T = K2/ln(K1/L\lambda + 1) \quad (6)$$

Where:

T : Temperature (oK)
$L\lambda$: spectral radiance values (Watts/(m2*sr*µm).
K1 : First thermal conversion constant of Landsat satellite
K2 : Second thermal conversion constant of Landsat satellite

Table 1. K1 and K2 thermal conversion constants of Landsat satellites (USGS, 2013)

Sensör		K1	K2
Landsat 5		607,76	1260,56
Landsat 8	Band 10	774,89	1321,08
	Band 11	480,89	1201,14

3. Results

Within the scope of the study, the water surface area in the satellite images was determined by firstly applying AWEI. Then, the spatial change that occurred between 1985 and 2020 was determined. The results of the AWEI technique applied to the satellite images are given in Fig 2. Looking at the results given in Table 2 and Fig 3, the spatial variation of the lagoon and the accuracy results of the method used can be reached. The resulting change is given in Table 3.

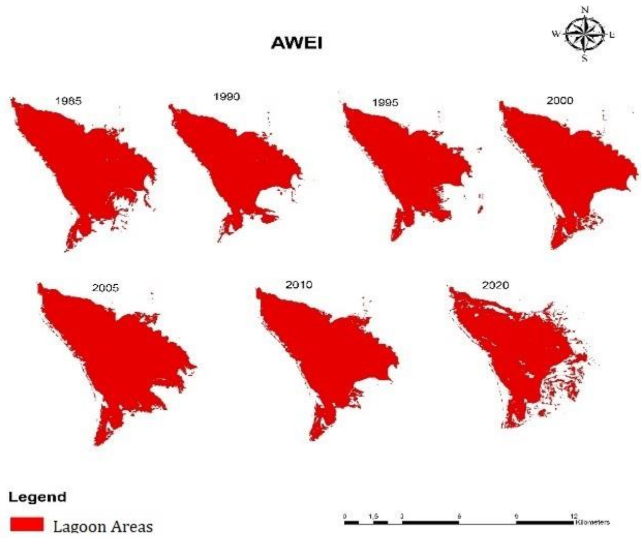

Figure 2. AWEI Index Results

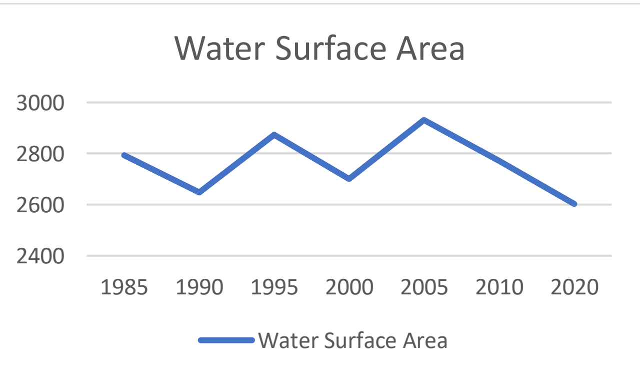

Figure 3. Water Surface Area (hectar)

Table 2. Areas and accuracy results calculated with AWEI index

Years	Water Surface Area (ha)	Overall Accuracy
1985	2794.14	99.00%
1990	2647.08	97.00%
1995	2873.34	94.00%
2000	2699.28	94.00%
2005	2931.39	91.00%
2010	2771.19	97.00%
2020	2602.71	97.00%

Table3. Area Changes

Years	Change (%)
1985-1990	-5.26%
1990-1995	+8.54%
1995-2000	-6.05%
2000-2005	+8.59%
2005-2010	-5.46%
2010-2020	-6.07%
1985-2020	-6.85%

Then, the temperatures of the Karina Lagoon water surface were determined by first converting the reflectance values of the thermal bands of Landsat 5 and Landsat 8 satellites to radiance and then converting the obtained radiance values to brightness temperature.

The change in the lagoon water temperature is given in Fig 4. and Table 4. The temperature changes are visualized on the graph given in Fig. 5.

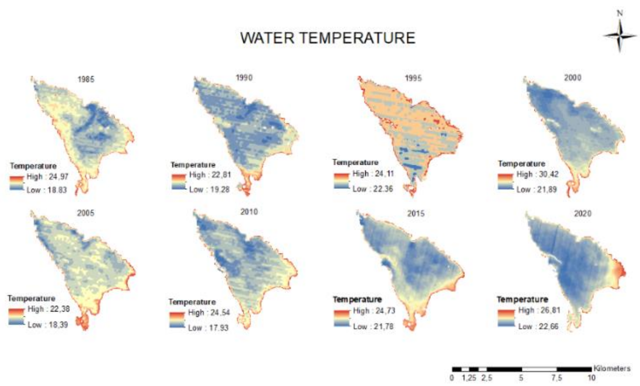

Figure 4. Water Temperature

Table 4. Water Surface Temperatures

	Water Temperature	
Years	Max (^{0}C)	Min (^{0}C)
1985	24.97	18.83
1990	22.81	19.28
1995	24.11	22.36
2000	30.42	21.89
2005	22.38	18.39
2010	24.54	17.93
2015	26.81	24.73
2020	22.66	21.78
Mean (^{0}C)	24.84	20.65

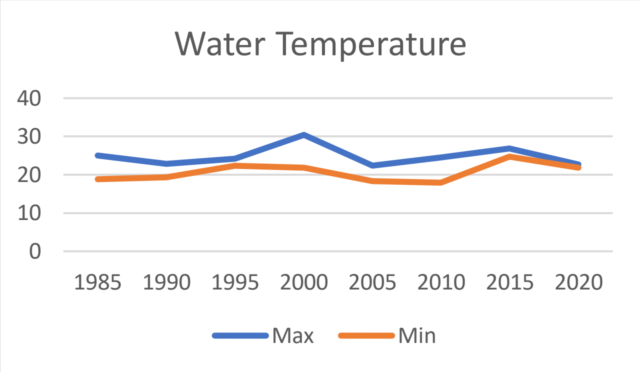

Figure 5. Water Surface Temperature (⁰C)

4. Conclusion & Discussion

In this study, 6 Landsat 5 satellite images belonging to the years 1985-2011 and 2 Landsat 8 satellite images belonging to the years 2011-2020 were used. While selecting satellite images, summer months with less cloudiness were preferred and all images were obtained from June of the relevant year. After the images used were preprocessed, the surface area of the Karina Lagoon was determined by applying the AWEI technique. By comparing the determined water surface areas with each other, the amount and direction of the spatial change was determined. In this context, when the results of the AWEI index are examined, there is no linear increase or decrease. The lagoon area, which was 2794.14 hectares in 1985, was measured as 2602.71 hectares in 2020. The lagoon reached its widest area in 2005 with 2931.39 hectares. The lagoon area decreased by 6.85% in total from 1985 to 2020. As a result of the accuracy analysis, the AWEI technique, which works with a minimum of 91% accuracy, has been successful in extracting the water body.

In addition to the spatial change, the lagoon surface water temperatures and the change trend of the temperatures were examined and compared. Surface water temperatures were calculated using the thermal bands of the Landsat satellite. The surface water temperature, which reached the highest measured temperature at 30,42⁰C in 2000, reached the lowest temperature at 17,93⁰C in 2010. Surface water temperatures average 24,84⁰C at the highest and 20,65⁰C at the lowest. When the lagoon water surface temperature changes are examined on the dates evaluated within the scope of the study, the water temperature, which is relatively lower in the inner parts of the lagoon, was measured higher in the coastal areas. (Şener, 2016).

References

Balçık, F. B. & Göksel, Ç. (2010). SPOT 5 ve Farklı Görüntü Birleştirme Algoritmaları. Jeodezi ve Jeoinformasyon Dergisi, (101), 0-0. Retrieved from https://dergipark.org.tr/tr/pub/hkmojjd/issue/53143/704637

Bekdemir Ü,Elmacı S & Sezer İ (2010). Turizmin kıskacında bir doğa koruma alanı: Dilek Yarımadası-Büyük Menderes Deltası Milli Parkı

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. Pages 23-35. ISSN 0034-4257, https://doi.org/10.1016/j.rse.2013.08.029

Gülci S, Gülci N & Yüksel K (2019). Monitoring Water Surface Area and Land Cover Change by Using Landsat Imagery for Aslantaş Dam Lake and Its Vicinity." *Journal of the Institute of Science and Technology* 9 (1): 100–110. https://doi.org/10.21597/jist.419221.

Liang S, 2004: Quantitative Remote Sensing of Land Surfaces, John Wiley and Sons, New Jersey, USA

Özçalık H, Torun A T & Bilgilioğlu S S (2020). Landsat uydu görüntüleri kullanılarak Mogan Gölü'nün su yüzeyi ve arazi örtü değişiminin belirlenmesi. Türkiye Uzaktan Algılama Dergisi

Song C, Woodcock C E & Seto K C (2001). Classification and change detection using Landsat TM data: when and how to correct atmospheric effects? Remote Sensing of Environment 75:230–44

Şener E (2016). Burdur gölü yüzey suyu sıcaklığı mevsimsel dğişiminin Landsat 8 uydu görüntüleri kullanılarak belirlenmesi. Mühendislik Bilimleri ve Tasarımları Dergisi

USGS., 2013. Landsat 8 (L8) Data Users Handbook Version 1.0

Xu H (2002). Spatial expansion of urban/town in Fuqing of China and itsdriving force analysis. Remote Sensing Technology and Application.

Yu J, Huang Y & Feng X (2001). Study on water bodies extraction and classification from Spot image. Jornal of Remote Sensing.