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DETERMINATION OF CLIMATE TYPE AND EVAPOTRANSPIRATION FOR BURDUR LAKE BASIN USING GEOGRAPHICAL INFORMATION SYSTEMS AND DIFFERENT METHODS

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Keywords

Burdur Lake Basin, Evapotranspiration, Climate Type, Geographic Information Systems.

Abstract

The surface area of Lake Burdur has been gradually shrinking every year. The most important factors causing this water loss are the climate type of the basin and evapotranspiration. In hydrogeological basin studies, one of the discharge parameters used in hydrological water balance calculations is the actual evaportranspiration. Thornthwaite, Blaney-Criddle and Schendel methods were used to calculate evapotranspiration for the basin. When the results of the three methods were compared, Thornthwaite method gave results closer to the average values. Thornthwaite Climate Classification method was chosen to determine the climate type by accepting that Thornthwaite method represents the basin climate characteristics. Precipitation index, humidity index and drought index were calculated to determine the climate type. Precipitation efficiency index values are in arid-semi humic (C1) climate type for all stations. Drought index value is 'very strong water deficit in summer' for all stations. (s2) and 'very strong water deficit in winter' (w2) precipitation regime. Moisture index values for all stations are in the precipitation regime of 'moderate water surplus in summer' (s) and 'moderate water surplus in winter' (w). It is concluded that Burdur Lake basin has arid-semi humic climate type and has arid climate class.

COĞRAFİ BİLGİ SİSTEMLERİ VE FARKLI YÖNTEMLER KULLANILARAK BURDUR GÖLÜ HAVZASI İÇİN İKLİM TİPİ VE EVAPOTRANSPİRASYONUN BELİRLENMESİ

Anahtar Kelimeler

Burdur Gölü Havzası, Evapotranspirasyon, İklim Tipi, Coğrafi Bilgi Sistemleri.

Öz

Burdur Gölü'nün göl yüzey alanı her yıl giderek küçülmektetedir. Bu su kaybına sebep olan en önemli unsurları olarak havzanın iklim tipi ve evapotranspirasyon gösterilebilir. Hidrojeolojik havza etütlerinde hidrolojik su bilançosu hesaplamalarında kullanılan boşalım parametrelerinden bir tanesi gerçek evaportranspirasyondur. Havza için evapotranspirasyon hesaplamasında Thornthwaite, Blaney-Criddle ve Schendel yöntemleri kullanılmıştır. Üç yöntemin sonuçları karşılaştırıldığında Thornthwaite yöntemi ortalama değerlere daha yakın sonuçlar vermiştir. Thornthwaite yönteminin havza iklim özelliklerini temsil ettiği kabul edilerek, iklim tipinin belirlenmesinde Thornthwaite İklim Sınıflandırma yöntemi seçilmiştir. İklim tipinin belirlenmesinde yağış indisi, nemlilik indeksi ve kuraklık indisi hesaplanmıştır. Yağış etkinlik indisi değerleri tüm istasyonlar için arid-semi humic (C1) iklim tipindedir. Kuraklık indisi değeri tüm istasyonlar için "yazın çok kuvvetli su noksanı" (s2) ve "kışın çok kuvvetli su noksanı" (w2) yağış rejimine sahiptir. Nemlilik indisi değerleri tüm istasyonlar için "yazın orta derecede su fazlası" (s) ve "kışın orta dercede su fazlası" (w) yağış rejimindedir. Burdur Gölü havzası kurak-yarı nemli iklim tipine sahip ve arid iklim sınıfına sahip olduğu sonucuna varılmıştır.

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Highlights

- Determination of climate type and evapotranspiration (ET) of Lake Burdur basin
- Comparison of ET calculation methods
- Evaluation of climate data calculated using meteorological station data in the basin in GIS

Graphical Abstract

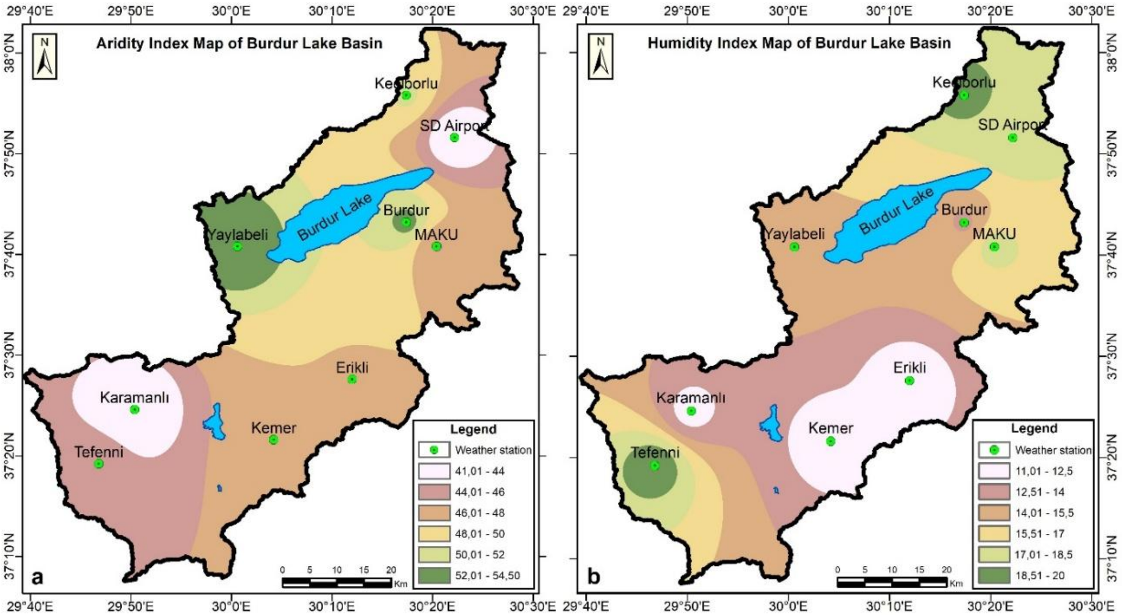

Figure. Aridity index (a) and humidity (b) maps of Burdur Lake Basin

Purpose and Scope

The aim of this study is to calculate ET and climate parameters for the Burdur Lake basin using different methods and to determine the dominant climate type. In addition to this main objective, the calculated climate parameters are converted into thematic maps in GIS environment.

Design/methodology/approach

In the study, a literature review of similar studies was conducted and analysed. Three of the ET calculation methods suitable for the study area were selected and used. The results of these methods were compared and it was concluded that the method closest to the actual evaporation values best represents the study area. Climate parameters used in determining the climate type were calculated using the data of meteorological stations in the basin area. The results obtained were analysed in cbs environment and thematic maps were prepared.

Findings

Three different ET calculation methods were used to analyse the actual evaporation values for the basin. Among these methods, it was determined that the Thornthwaite method gives the closest results to the actual pan evaporation values and is the most suitable calculation method for the basin. Dominant climate classifications were determined from the climate parameters calculated according to the meteorological station data in the study area. These parameters were analysed in GIS environment and thematic maps were prepared. Accordingly, it was concluded that Burdur Lake basin has arid-semi humic climate type and has arid climate class.

Originality

No previous study on ET calculation methods and climate classifications in the basin has been found in the literature. The ability of the calculation methods to represent the study area was checked by comparing with actual pan evaporations. It was shown that the Thornthwaite method can produce remarkable results for areas with similar climatic characteristics. In addition, the prevailing climatic characteristics were revealed by determining the climatic parameters and the role of climatic characteristics in the water losses in Lake Burdur was determine

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1. Introduction

The most crucial task in hydrogeological studies of a basin is the preparation of a water budget. Groundwater budget calculations are generally used to assess the sustainability of withdrawals for different purposes. The results of the groundwater budget provide information on significant external groundwater changes and support stakeholders in managing groundwater resources (Viaroli *et al.,* 2018). The groundwater budget operates on the assumption that the amount of water entering and exiting an aquifer, which is assumed to be in balance during a designated time frame, is equivalent. This period also considers the variation in water stored inside the aquifer. Calculations pertaining to alterations in recharge and discharge, including future projections, are termed the groundwater budget. Formulating the groundwater budget aims to determine the sustainable groundwater draw from the basin. Groundwater extraction must not surpass the natural recharge rate (Demiroğlu, 2017). The safe groundwater reserve defines the maximum volume of water that can be withdrawn from the aquifer without causing its depletion throughout the specified budgetary term.

Numerous research studies have been undertaken on the fluctuations in water levels of Lake Burdur. The investigations identified the causes of the water level reduction as changes in meteorological data, changes in surface runoff, excessive groundwater extraction, and poor land utilization (Kansoh *et al.,* 2020; Gözükara *et al.,* 2019; Ataol, 2010). Researchers have examined the abrupt declines in water levels of Lake Urmia, Iran, by analyzing the relationship between hydro-meteorological variables and components of the water budget. This study concluded that precipitation and evaporation could modify the groundwater and flow dynamics within the basin (Vaheddoost *et al.,* 2022). A study that looked at evapotranspiration (ET) in the irrigated ecosystem of the Qinghai Lake basin on the Tibetan Plateau found that it is important for environmental protection to understand the water balance of ET (Cao *et al.,* 2020).

The factors contributing to the recent reductions in water levels of Lake Bracciano, Italy's seventh largest lake, have been examined. This study analyzes the hydrogeological water budget, climate change, and anthropogenic effects (Filippi and Sappa, 2024). The drought experienced in the Mediterranean Region over the past decade has inflicted significant harm on water ecosystems and their management (Guion *et al.,* 2022; Mathbout *et al.,* 2021; Oroud, 2018).

In hydrological water budget calculations, two groups of parameters are used: recharge and discharge. The recharge parameters include precipitation, groundwater recharge, surface runoff recharge, and artificial recharge through irrigation. The discharge parameters consist of evaporation, groundwater flow, surface runoff, and groundwater extraction via boreholes (Robertson *et al.,* 2022). Discharge parameters include evaporation, groundwater flow, surface runoff, and groundwater extraction through drilling (Martin and Yang, 2023). Precipitation and evaporation values are directly calculated using meteorological data, while hydrological and hydrogeological methods are employed to determine the other parameters. In the calculation of ET, the latitude of the study area, monthly average temperature, and monthly average precipitation values are used. These values vary depending on the climate classification of the study area. The temporal decline in the water level of Lake Burdur highlights the significance of evaporation values (Soyaslan and Hepdeniz, 2016).

ET and climatic factors significantly affect a region's water budget, which is crucial for water resource management, evaluating drought effects, and comprehending local hydrological cycles. ET, encompassing both evaporation and plant transpiration, directly influences groundwater levels, soil moisture, and surface water supplies. Changes in climatic factors such as temperature, humidity, and solar radiation, which impact water availability and regional hydrological cycles, influence variations in ET rates (Hu and Mo, 2022; Wang *et al.,* 2022).

Climate can be defined as the variations in all weather events observed throughout the year in a given region. Meteorological data, explained based on long-term observations and measurements, are referred to as climate characteristics. Turkey is located on a transition zone for global air masses. Most of Turkey lies in the subtropical belt, with polar climatic conditions dominating the north and macroclimatic zones prevailing in the south (Aydın *et al.,* 2019; Öztürk *et al.,* 2017; Bölük, 2016). In recent years, studies have been conducted using Geographic Information System (GIS) technologies to investigate the elevation-dependent variations of key climate parameters and climate zones (Aydın *et al.,* 2019). However, it has been determined that there is a discrepancy between thematic maps derived from station data and those based on elevation correlations (Yılmaz and Çiçek, 2018). Therefore, climate characteristics do not show a direct variation based solely on elevation.

Climate has a significant impact on human life. Due to this influence, climate has been classified into various types. The primary purpose of determining climate classes is to delineate the boundaries of similar and distinct climate types worldwide (İrcan and Duman, 2021; MGM, 2016). Identifying climate characteristics in a basin is crucial for all hydrological and hydrogeological studies conducted on a basin scale (Aydınözü and Sözcü, 2020). This is because meteorological data are inevitably used in all hydrological and hydrogeological studies, and climate characteristics play a key role. Climate directly or indirectly influences all natural and human activities on Earth. Therefore, determining the climate characteristics of a region is of great importance.

Climatic conditions with different characteristics are represented by various climatological classifications. Numerous climate classification methods are employed in the classification of climates. Some of these methods include De Martonne, Erinç, Holdridge, Köppen, Trewartha, Palmer, and Thornthwaite (İrcan and Duman, 2021). In this study, the Thornthwaite method was used for climate classification. The Thornthwaite climate classification is essentially based on the relationship between precipitation-evaporation and temperature-evaporation. In the Thornthwaite method, when precipitation exceeds evaporation, the soil becomes saturated with water, resulting in water surplus. In such cases, the climate can be described as humid. Conversely, when precipitation is less than evaporation, there is no water in the soil, leading to water deficiency. In this case, the climate is defined as arid. The Thornthwaite climate classification varies between two values: water surplus and water deficiency (MGM, 2016).

2.. Material and Method

2.1. Study Area

The study area is located within the provincial boundaries of Burdur and Isparta, encompassing Lake Burdur, and the districts of Kemer, Tefenni, Karamanlı, and Keçiborlu. The Burdur Lake basin covers an area of approximately 81.55 km^2 between 29°40'-30°30' East longitude and 37°05'-38°05' North latitude (Figure 1).

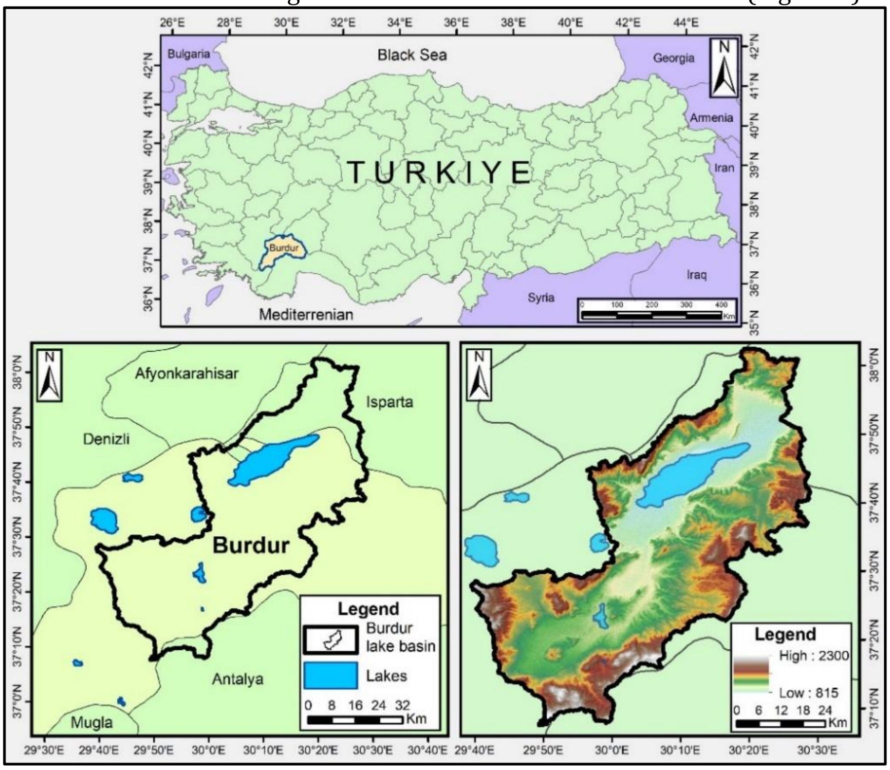

Figure 1. Location map

The basin is a depression plain surrounded by high mountains, located within the boundaries of the 1:100,000 scale topographic map sheets L24, M23, M24, N23, and N24. The southern part of the study area is bordered by the Western Taurus Mountains, with elevations reaching up to 2250 meters. The lowest elevation is at the water level of Lake Burdur, which drops to approximately 846 meters. The basin, characterized as a depression plain, is bounded by high mountains to the north and south, with the central part where Lake Burdur is located having lower elevations.

One of the most significant environmental issues within the Burdur Lake basin is the decline in the lake's water level. Over time, this has led to a noticeable shrinkage of Lake Burdur. In recent years, the construction of dams and ponds on the rivers that feed the lake has been cited as one of the reasons for the reduction in its water level (Soyaslan and Hepdeniz, 2016). Additionally, the expansion of irrigated agricultural areas, increased groundwater use, and changes in climate characteristics are thought to contribute to this issue. It is necessary to determine the climate type and ET to assess their impact on the lake's decreasing water level.

The basin distinguishes between autochthonous and allochthonous geological units. The autochthonous units include the Oligocene-aged Karaburun Formation, the Pliocene-aged Burdur Formation, Quaternary-aged alluvium, colluvium, and alluvial cones. The allochthonous unit is represented by the Mesozoic-aged Gökçebağ ophiolitic melange (Ala, 2001).

2.2. Proposed Method

Potential evapotranspiration (ETp) is the maximum amount of water lost through evaporation and transpiration under specific climatic conditions. Actual evapotranspiration (ETa) refers to the ET that transpires in accordance with the monthly average precipitation volume (Soyaslan, 2004). Etp and Etr are computed utilizing numerous parameters and distinct methodologies. The Etp and Etr values were calculated using the Thornthwaite (Thornthwaite, 1948) , Blaney-Criddle (Blaney and Criddle, 1950) and Schendel methods (Schendel, 1968). For each of these three methods, the precipitation, temperature, and relative humidity values measured at nine meteorological stations in the basin were used. These nine meteorological stations are Burdur, Erikli, Kemer, Yaylabeli, Karamanlı, MAKU, Tefenni, SD Airport, and Keçiborlu stations (Figure 2).

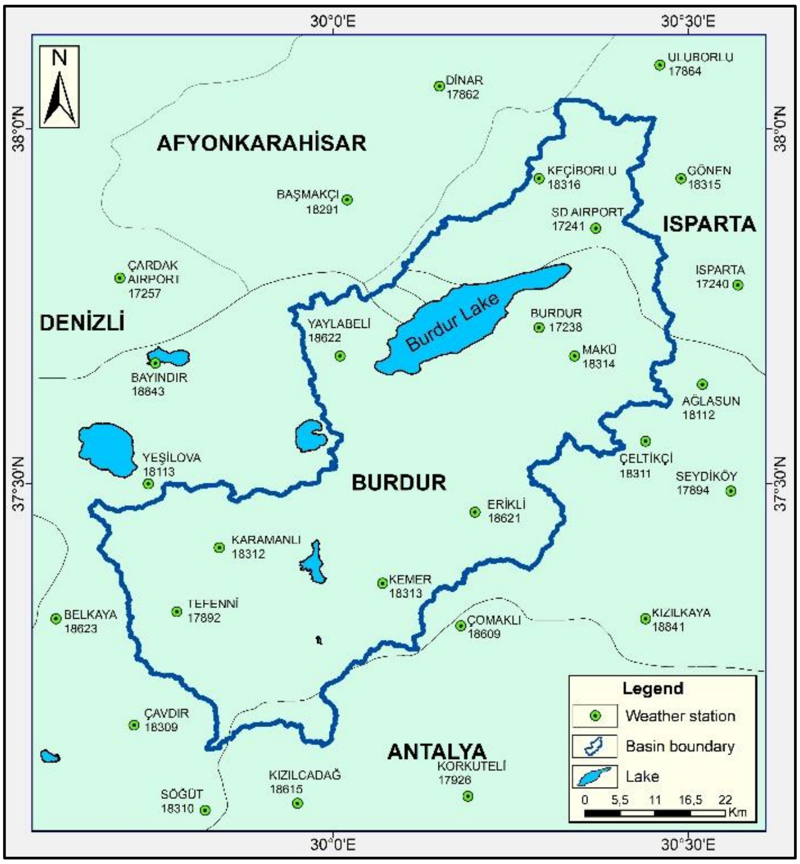

Figure 2. Location map of meteorological stations

2.2.1. The thornthwaite method

The Thornthwaite method utilizes average monthly temperature and latitude correction coefficients to calculate ETp values. The expressions and formulas used in the Thornthwaite method are provided below (Thornthwaite, 1948). The monthly temperature index is given in Equation 1, the annual total temperature index is presented in Equation 2, the coefficient 'a' is shown in Equation 3, and Etp is specified in Equation 4.

$$i = \left(\frac{t}{5}\right)^{1.514} \quad (1)$$

$$I = \sum_{1}^{12} i \quad (2)$$

$$a=6.7510 * 10-7 * I3 - 7.7110 * 10-5 * I2 + 1.791210 * 10-2 * I + 0.49239 \quad (3)$$

$$ETp = 16 * \left(\frac{10 * t}{I}\right)^{a} * p \quad (4)$$

t: Monthly average temperature (°C)
i: Monthly temperature index
I: Annual total temperature index
ETp: Monthly potential ET amount (mm)
p: Latitude correction coefficient.

The latitude correction coefficient (G) used in the calculation of monthly ET is a value prepared based on average sunshine duration. It varies according to the latitude of the meteorological station and has been published by Thornthwaite.

2.2.2. Blaney-Criddle method

The Blaney-Criddle method utilizes average monthly temperature and latitude correction coefficients in the calculation of ETp values. The Etp formula in the Blaney-Criddle method is presented in Equation 5 (Blaney and Criddle, 1950).

$$ETp = 25.4 * t * p \quad (5)$$

ETp: Monthly potential ET amount (mm),
t: Monthly average temperature (°C),
p: Latitude correction coefficient.

2.2.3. Schendel method

The Schendel method utilizes average monthly temperature and average relative humidity values in the calculation of ETp. The ETp formula in the Schendel method is presented in Equation 6 (Schendel, 1968).

$$ETp=\frac{t}{H * 480} \quad (6)$$

ETp: Monthly potential ET (mm),
t: Monthly average temperature (°C),
H: Average monthly relative humidity (%).

2.2.4. Thornthwaite precipitation index

According to Thornthwaite, climates are classified into two categories—humid and arid—based on the relationship between precipitation and ET (Table 1). The results obtained using the precipitation effectiveness index formula are categorized according to the letters and climatic characteristics outlined in this table (İrcan and Duman, 2021; Türkeş, 2010; Birsoy and Ölgen, 1992; Ardel *et al.,* 1969). The Thornthwaite precipitation index formula is presented in Equation 7.

$$I_m=\frac{(100 * s) - (60 * d)}{ETp} \quad (7)$$

Im: Precipitation effectiveness index,
s: Annual water surplus (mm),
d: Annual water deficit (mm),
ETp: Annual potential ET (mm).

Table 1. Thornthwaite Precipitation Efficiency Index and climate characteristic

I_m	Symbol	Climate type	
>100	A	Very humid	Humid climate
100-80	B4	Humid	
80-60	B3	Humid	
60-40	B2	Humid	
40-20	B1	Humid	
20-0	C2	Semi-humid	
0-(-20)	C1	Drought-semi humid	Drought climate
(-20)-(-40)	D	Semi-drought	
(-40)>	A	Full drought	

2.2.5. Thornthwaite drought index

One of the Thornthwaite precipitation regime indices is the drought index. The drought index is generally used for humid climates where precipitation is abundant. The formula for the drought index (Ia) is presented in Equation 8.

$$I_a = \frac{100 * d}{P} \quad (8)$$

d: Annual water deficit (mm),
ETp: Annual potential ET (mm).

The classification of the Thornthwaite drought index is presented in Table 2 (Yılmaz and Çiçek, 2020; MGM, 2016; Birsoy and Ölgen, 1992).

Table 2. Thornthwaite aridity index classification

I_a	Symbol	Climate type
0-16.7	r	No or very little water deficiency
16.8-33.3	s	Moderate water deficiency in summer
16.8-33.3	w	Moderate water deficiency in winter
$33.4<I_a$	s2	Very strong water deficiency in summer
$33.4<I_a$	w2	Very strong water deficiency in winter

2.2.6. Thornthwaite humidity index

One of the Thornthwaite precipitation regime indices is the humidity index. The humidity index is typically used for arid climates where precipitation is low. The formula for the humidity index (I_h) is given in Equation 9.

$$I_h = \frac{100*s}{Etp} \quad (9)$$

In Equation 9, s represents the annual water surplus (mm) and Etp (mm) represents the annual potential evaporation. The Thornthwaite moisture index classification is provided in Table 3 (Yılmaz and Çiçek, 2016; MGM, 2016; Birsoy and Ölgen, 1992).

Table 3. Thornthwaite humidity index classification

I_h	Symbol	Climate type
0-10	d	No or very little water surplus
11-20	s	Moderate water surplus in winter
11-20	w	Moderate water surplus in summer
$21<I_h$	s2	Very strong water surplus in winter
$21<I_h$	w2	Very strong water surplus in summer

2.2.7. Geopgraphic information systems

The Etp, Etr, water surplus, and water deficit values obtained from the adjusted water budget derived through the Thornthwaite method were transferred to a GIS environment. Point-based meteorological station data were converted into raster data representing the entire basin using the Inverse Distance Weighting (IDW) method. The IDW interpolation method is based on weighting the inverse of the distance between data points and the point to be estimated. In the IDW method, the main goal is to reduce the influence of distant points on the predicted value as the distance from the data points increases. The standard IDW method does not impose any restrictions on the selection of data points (Khouni *et al.,* 2021; Göğsu and Hastaoğlu, 2019; Luo *et al.,* 2008).

3. Results and Discussions

3.1. Evapotranspiration (ET) Methods

The Thornthwaite, Blaney-Criddle, and Schendel methods were used to calculate the ETp and ETa values for the Burdur Lake Closed Basin. ETa graphs were prepared using data from nine different meteorological stations within the study area (Figure 3).

When comparing the three methods used in the calculation in terms of ETa values, it is observed that the values from the Blaney-Criddle method are lower, while those from the Schendel method are higher. The Etr values obtained from the Thornthwaite method generally fall between the two. In the Thornthwaite method, the ETa value reached its maximum in June, when the soil moisture reserve was depleted. After the depletion of the soil reserve, the ETa value in July decreased, as it only reflected the amount of available precipitation.

In the Blaney-Criddle method, a simple formula is used to calculate Etr values by applying a latitude correction factor and monthly average temperatures. Consequently, the Etr values obtained from this method tend to be below average, yielding very low results. As a result, it cannot be said that this method fully represents the climatic characteristics of the study area.

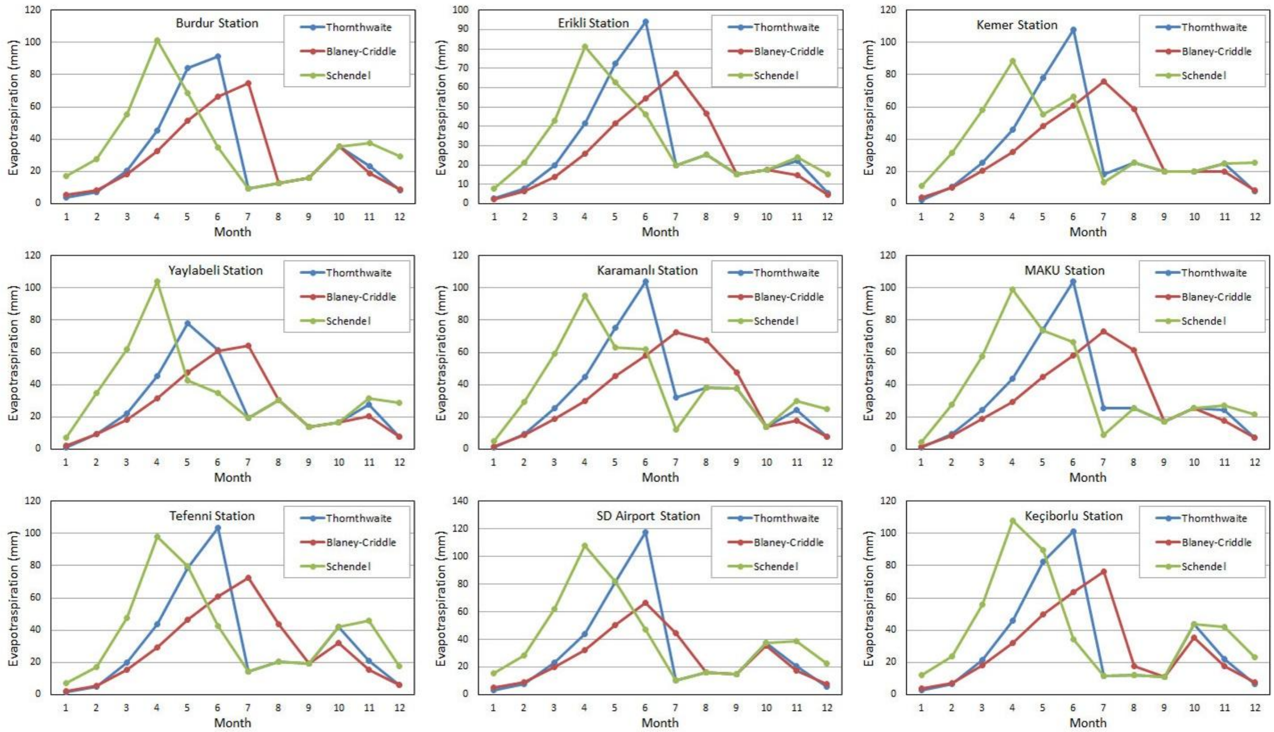

Figure 3. Actual evapotranspiration (ETa) graphs obtained by different methods for Burdur Lake Closed Basin stations

The Schendel method is more applicable to countries like Germany, which have higher rainfall, resulting in higher Etr values. Thus, it depletes the soil moisture reserve around April and reaches maximum values. In the following months, since Etr occurs at the same rate as the amount of precipitation, the Etr value decreases rapidly. It can be said that this method is more suitable for regions in Turkey with a climate similar to the Black Sea, where rainfall is more prevalent.

As a result of all these evaluations, it was concluded that the Thornthwaite method represents the study area better than the other methods. This result was also found to be consistent with previous studies (Soyaslan, 2004; Ala, 2001). In determining climatic characteristics, the data from the adjusted water budget table obtained through the Thornthwaite method were utilized (Table 4).

Table 4. Thornthwaite method water balance

Stations	Etp (mm)	Precip (mm)	Etr (mm)	Water deficiency (mm)	Water surplus (mm)
Burdur	754.79	395.97	356.63	398.16	103.63
Erikli	658.72	332.08	326.27	332.46	74.86
Kemer	736.76	394.22	385.86	350.90	85.24
Yaylabeli	729.79	390.16	332.22	397.56	112.78
Karamanlı	703.63	435.23	413.22	290.40	83.32
MAKU	705.87	445.62	382.05	323.81	124.31
Tefneni	697.35	472.67	375.90	321.46	137.23
SD Airport	763.29	483.51	382.03	381.25	139.32
Keçiborlu	739.93	473.73	367.54	372.39	140.92

According to the Thornthwaite method, the highest Etp values were recorded at the SD Airport, Burdur, and Keçiborlu stations. These three stations are located near the lake and have the lowest elevation values. The highest Etr values, on the other hand, were obtained at the Karamanlı, Kemer, and Makü stations. It is observed that the elevation values of these stations are higher compared to the other stations (Figure 4). The primary reason for the differing Etp and Etr values between the Burdur (957 m) and MAKU (1230 m) stations, which are geographically very close to each other, is their difference in elevation.

According to the Thornthwaite method, the highest water deficit values were recorded at the SD Airport, Burdur, and Keçiborlu stations. These three stations are located near the lake and have the lowest elevation values. In contrast, the highest Etr values were obtained at the Karamanlı, Kemer, and Makü stations, which are observed to have higher elevation values compared to the other stations (Figure 4). The primary reason for the differing Etp and Etr values between the Burdur (955 m) and MAKU (1220 m) stations, which are very close to each other geographically, is their difference in elevation. The most significant evidence for this is that the Erikli station, which has the lowest Etp and Etr values, also has the highest elevation at 1357 m.

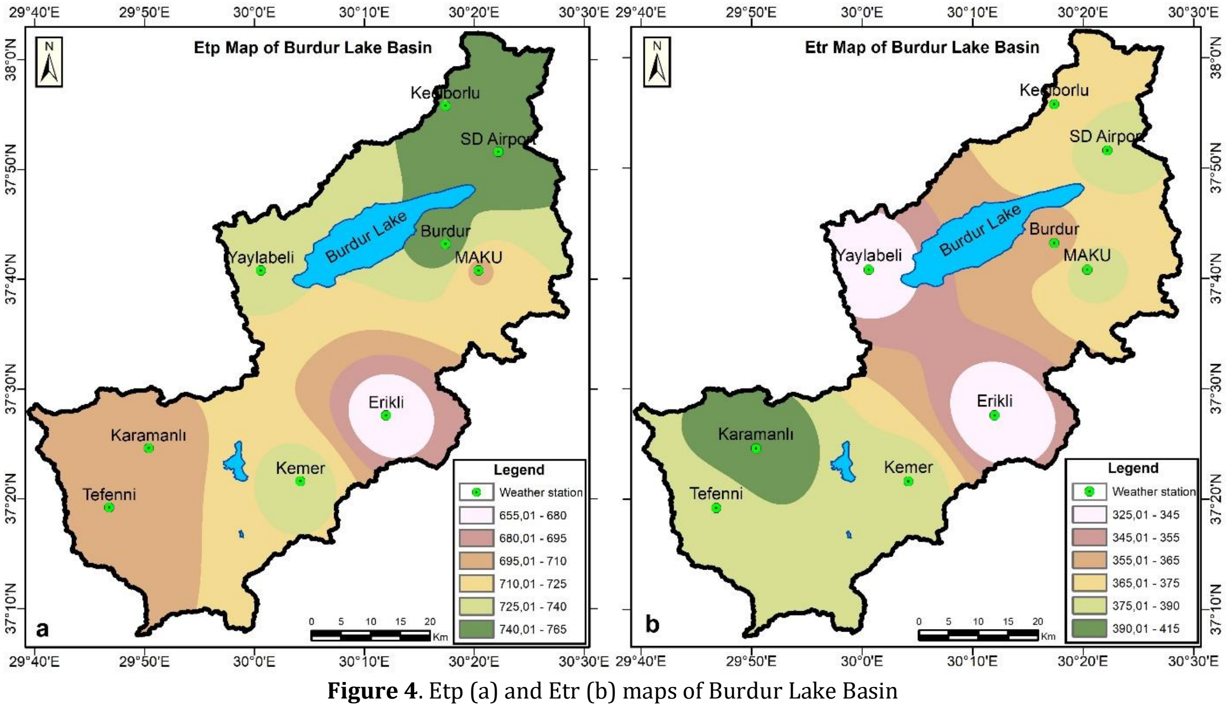

Figure 4. Etp (a) and Etr (b) maps of Burdur Lake Basin

According to the Thornthwaite method, the highest water deficit values were recorded at the Yaylabeli (398 mm), Burdur (398 mm), and SD Airport (381 mm) stations. Among these, the SD Airport (869 m) and Burdur (957 m) stations have the lowest elevations in the basin (Figure 5). Additionally, obtaining water deficit values at the three stations surrounding Burdur Lake is a significant finding. The lowest water surplus value, on the other hand, is primarily concentrated in the southwestern part of the basin, particularly at the Karamanlı station. It is evident that there is a marked decrease in water surplus from the northeast to the southwest of the basin.

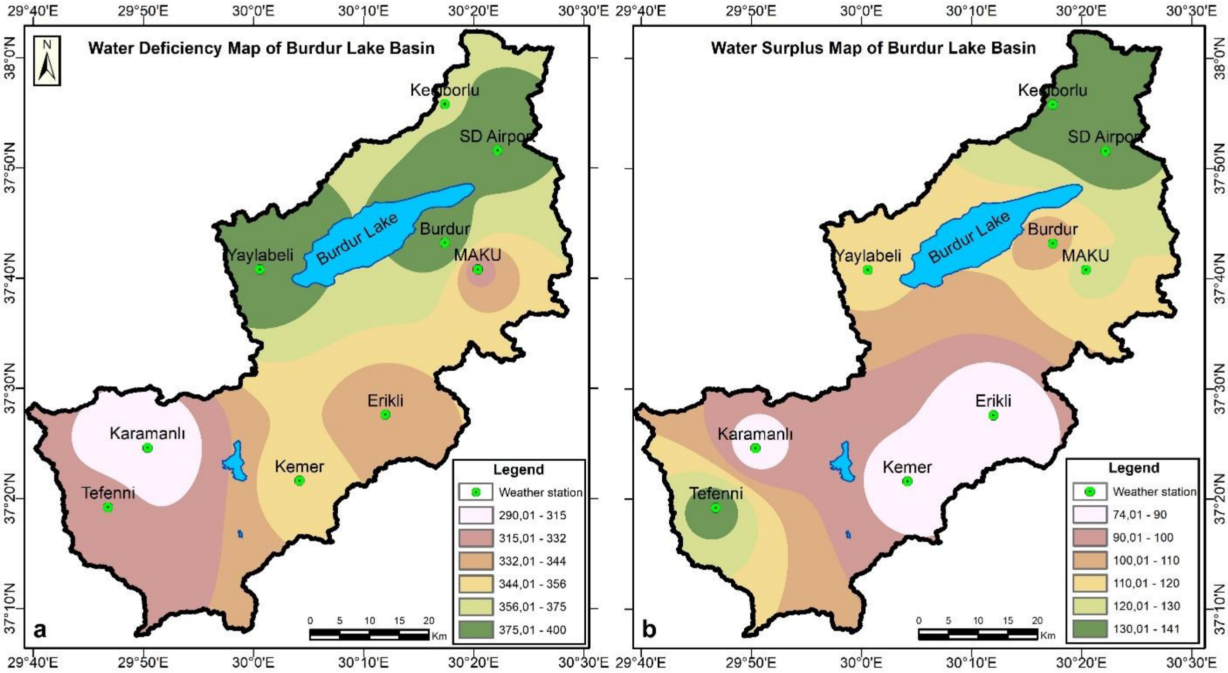

Figure 5. Water deficiency (a) and water surplus (b) maps of Burdur Lake Basin

There is a noticeable decrease in water deficit from the northwest to the southeast of the basin. At the Tefenni station, located in the far southwestern part of the basin, the water deficit value increases again. The highest water deficit values are recorded at the Keçiborlu (141 mm), SD Airport (139 mm), and Tefenni (137 mm) stations, respectively. The primary reasons for the high water deficit values at these stations are the elevated Etp values and the early depletion of the soil moisture reserves. In contrast, the lowest water deficit values are found at the Erikli (75 mm), Karamanlı (83 mm), and Kemer (85 mm) stations, which are situated in the central part of the basin.

3.2. Thornthwaite Climate Classification Indices

The annual total Etp values, annual total water deficit, and annual total water surplus obtained from the Thornthwaite adjusted water budget calculations were used to compute the precipitation effectiveness indices (Table 5).

Table 5. Thornthwaite precipitation regime indices

Stations	Precipitation activity index (Im)	Aridity Index (I_a)	Humidity Index (I_h)
Burdur	-17.91	52.74	13.73
Erikli	-17.33	47.83	11.36
Kemer	-17.09	47.76	11.57
Yaylabeli	-17.23	54.48	15.45
Karamanlı	-12.92	41.27	11.84
MAKU	-9.91	45.87	17.61
Tefenni	-7.44	45.19	19.68
SD-Airport	-6.79	41.29	17.98
Keçiborlu	-11.15	50.33	19.05

For the study area, the calculated Thornthwaite Precipitation Activity Index (Im) ranged between 0 and -20 for all meteorological stations. According to the Thornthwaite precipitation effectiveness index, the entire basin falls within the 'arid-semi-humid' (C1) climate type and is classified as an arid climate.

The Aridity Index (I_a) values obtained for all stations were greater than 33.4. Accordingly, all stations within the basin exhibit a 'very strong water deficit in summer' (s2) and 'very strong water deficiency in winter' (w2) rainfall regime. The Humidity Index (I_h) values were calculated to range between 10 and 20 for all stations. Based on these results, all stations in the basin have a 'moderate water surplus in summer' (s) and 'moderate water surplus in winter' (w) rainfall regime. The Aridity and Humidity Index values were used to prepare thematic aridity and humidity maps in a GIS environment (Figure 6).

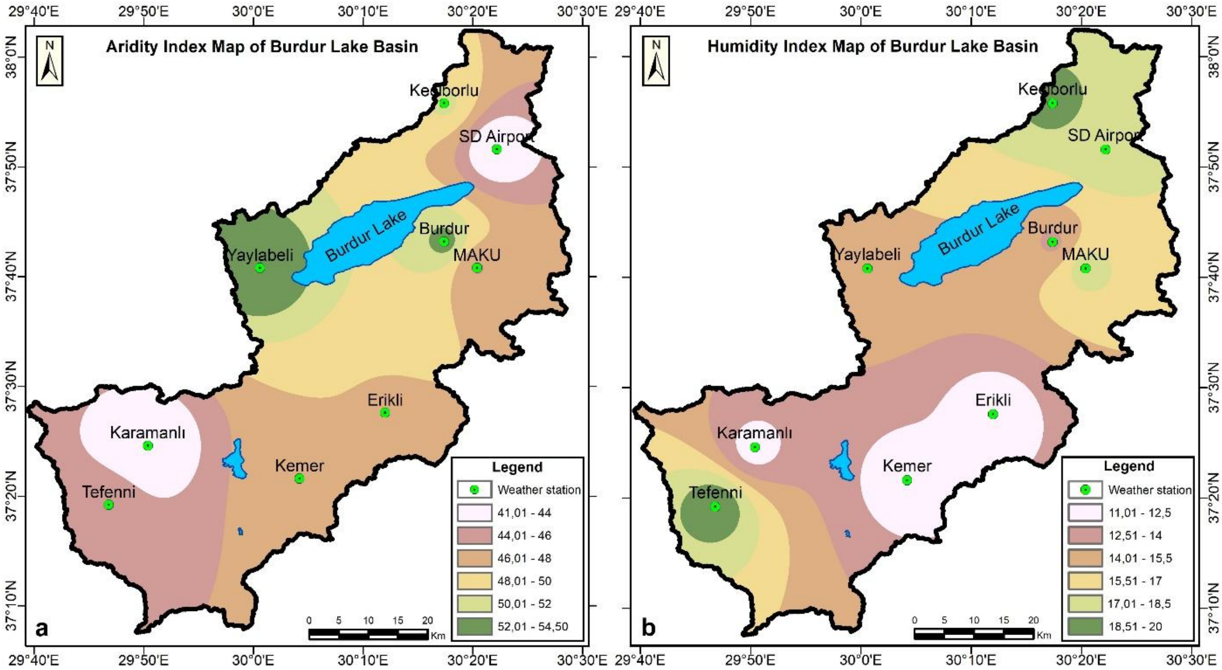

Figure 6. Aridity index (a) and humidity (b) maps of Burdur Lake Basin

According to the aridity index map, the highest values in the study area belong to the Yaylabeli (54.48) and Burdur (52.74) stations, while the lowest values are observed at the Karamanlı (41.27) and SD Airport (41.29) stations. Based on the humidity index map, the highest values are recorded at the Tefenni (19.68) and Keçiborlu (19.05) stations, while the lowest values are found at the Erikli (11.36), Kemer (11.57), and Karamanlı (11.84) stations. In conclusion, the aridity and humidity index values indicate the presence of a dominant rainfall regime within the basin.

4. Conclusions

ET estimations in the Burdur Lake Closed Basin were derived from data collected at meteorological stations in Burdur, Erikli, Kemer, Yaylabeli, Karamanlı, MAKU, Tefenni, SD Airport, and Keçiborlu. A comparative water budget analysis was performed in the research area utilizing the Thornthwaite, Blaney-Criddle, and Schendel methodologies. Of the three approaches evaluated, using climatic factors and pan evaporation data from meteorological stations, the Thornthwaite method has been identified as the most appropriate for portraying the basin. This result is consistent with previous studies conducted in the region

Using the Thornthwaite method, climate classification indices for the basin—namely the precipitation activity index, aridity index, and humidity index—were calculated. Thematic maps were generated using the IDW interpolation method in a GIS environment based on these index values.

For the study area, the precipitation activity index (Im) was found to range between 0 and (-20) for the entire basin. According to the precipitation activity index classification, the Burdur Lake basin is categorized under the "dry-subhumid" (C1) climate type and falls within the arid climate class.

The aridity index (I_a) values were found to exceed 33.4 at all stations. The Burdur Lake basin exhibits a "very strong water deficit in summer" (s2) and a "very strong water deficiency in winter" (w2) rainfall regime. Humidity index (I_h) values across the entire basin were calculated to range between 10 and 20. Based on these results, all stations within the basin possess a "moderate water surplus in summer" (s) and a "moderate water surplus in winter" (w) rainfall regime.

It has been concluded that climatic characteristics have contributed to the observable decrease in the water level of Burdur Lake over the years. Notably, high ETp values were recorded for the Burdur, SD Airport, and Keçiborlu stations, located at low elevations to the north of the lake. Similarly, the highest water deficit values were observed at the Burdur, SD Airport, and Yaylabeli stations surrounding the lake. The stations with the highest aridity index values are Burdur and Yaylabeli. Consequently, significant drought and water deficiency have been identified around the Burdur Lake region.

Conflict of Interest

No conflict of interest was declared by the authors.

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