



Impact of tourists on urban water needs in Marmaris, Türkiye

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Abstract

Water is one of the most basic necessities of humans, both for survival and environmental improvement. With the ongoing population growth and climate change, limited water resources are being consumed rapidly. Due to the rapid depletion of resources, the problem of water scarcity is also becoming increasingly common throughout the world. In this study, we analyze the current water potential of Marmaris, which is one of the important tourism regions of Türkiye. We aim to determine for how long the water resources will be sufficient to supply the region, along with its relationship with population and urbanization. To conduct these analyses, the population projections (winter population and tourist population) were calculated using the exponential regression method, and the amount of water needed by these populations was also calculated. A controlled classification method was used to associate land use data with population projections. As a result of these analyses, it has been determined that urbanization in Marmaris is much faster than population growth, and the existing water resources will be sufficient until approximately 2045.

Keywords Marmaris · Water demand · Tourism population · Water scarcity · Water resources · Türkiye

1 Introduction

Water resources play an important and inevitable role in the socio-economic development of countries and regions (McGinn et al., 2021). With the ongoing population growth around the world, the demand for limited land and water resources is also increasing (Grey et al., 2014). Changes in land use as a result of population growth and urbanization affect the flow regime and current water resources (Kassouri, 2021; Anand

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et al., 2018; Gashaw et al., 2018). Although the increase in flow rate and the decrease in seepage are typical effects of urbanization, it has many effects on hydrological processes (Berihun et al., 2019; Ahiablame & Shakya, 2016). The effects of land use on hydrological processes have been revealed in studies (Gashaw et al., 2018; Yin et al., 2017; Gebremicael et al., 2013; Li et al., 2018).

The population is one of the most important factors in changes in land use due to urbanization. (Xu et al., 2020). Therefore, the relationship between population growth and land use should not be ignored. In areas with rapid urbanization, meeting residential and industrial demands is one of the main challenges in these areas. Insufficient water resources, deterioration of water quality, and environmental pollution are common problems in these areas (Qin, Su, & Khu, 2011). At the same time, one of the reasons for the increase in pollution in global freshwater ecosystems is the increase in urban land use (Luo et al., 2020). In addition, rapid population growth directly causes a large increase in water demand (Maja & Ayano, 2021). And the increase in the global population is expected to continue, reaching 8.5 billion in 2030 and 9.7 billion in 2050 (United Nations, 2019). With the increase in the population, the increase in water demand is expected to continue in the coming years. (Boretti & Rosa, 2019). Therefore, for the sustainability of water resources, both the increase in population and the hydrological effects of changes in land use should be considered (Aghsaei et al., 2020).

Significant changes in the population are observed throughout the year in regions such as Marmaris, where coastal tourism is intense (Koç et al., 2017). Tourism in these regions should be sustainable as it plays an active role in the economy. Seasonality, which is one of the most important factors affecting sustainability in tourism, shows its effect more intensely in regions such as Marmaris (Cisneros-Martínez et al., 2018; Vergori, 2012). This causes a serious increase in the population of Marmaris in certain months. Considering the foreign visitors coming to Marmaris in 2021, it is seen that more than 36% of them came to Marmaris in August (Republic of Türkiye Ministry of Culture and Tourism, 2021). In Marmaris, where the seasonality effect is clearly seen, maximum water demand occurs in the summer months when water resources are at their minimum level (Toth et al., 2018). At the same time, the amount of water consumed by tourists during their stay in hotels is higher than the amount of water they consume at home (Okello et al., 2015). Studies have shown how high the per capita water use is, especially in hotels with high standards (Tirado et al., 2019; Becken, 2014). However, the amount of water consumed in the tourism sector is not exactly known. In order to determine this, many areas such as the daily water consumption of tourists, the amount of water used in the production of food products consumed by tourists, and the amount of water used in touristic activities should be considered. (Gössling et al., 2012). This makes the work very complex and challenging.

This study aims to determine the drinking and utility water needs of Marmaris, a region with heavy tourism activity. The study provides an analysis of population projections until the year 2060, present and future water needs, and the relationship between population and land use changes. This study differs from other studies by examining both the effect of population growth on drinking and utility water and the effect on land use. Considering that the ongoing increase in the population will continue, it is obvious that the need for water will also increase. At the same time, considering the global warming problem, this and similar studies will be important to prevent and/or decrease these problems' effects, and they will gain more importance year by year. The study presents a novel method by evaluating data such as tourism population and land use in a tourism region and giving a projection of the year in which water scarcity may occur. It is thought that this study will

fill the research gap on how long the water needs of the population changes of touristic cities will be sustainable.

2 Materials and methods

2.1 Study area

Marmaris is a significant port and coastal city at the confluence of the Mediterranean and Aegean Seas because of its geographic location. As a result, from the beginning of time till the present, it has served as a significant crossing point between the Aegean and the Mediterranean. Due to the region's indented coastal topography, well-preserved bays, and proximity to harbors, Marmaris and its surroundings have become a crucial link between Asia, Europe, and Africa. Balan Mountain, Karada and Günlük Hills in the east, the Datça Peninsula and Kerme Gulf in the west, the Ula Mountain in the north, the Karada and Günlük Hills in the east, and the Mediterranean Sea in the south encircle Marmaris. The coordinates for Marmaris are 36.8571 latitude and 28.2692 longitude.

The summers are quite hot and dry, and the winters are comparatively warm and rainy in regions where the Mediterranean climate is predominant. Due to the orographic positioning of the mountains, Marmaris is one of the regions with the highest rainfall after Rize in Türkiye, with annual precipitation over 1200 mm. Floods can be seen from time to time in the area due to heavy rains during the winter months.

Since Marmaris is a well-known summer and sea tourism location in the world, the population distribution of the region is concentrated in the city center and coastline of the area. Urbanization has also increased rapidly due to the increasing population, especially on the coastline. While the resident population of Marmaris is based on 90,000 in 2021, it is known that the annual number of tourists coming to the city is about 4 times the resident population. Marmaris provides drinking water from Marmaris Dam. Marmaris Dam provides 22.39 hm³ of water per year to the city (Muğla Governorship, 2014). The location and placement of Marmaris, which is being examined as a study area, in Türkiye is given in Fig. 1.

2.2 Data collection

The researchers required a large amount of data to examine the effects of urbanization and population change on water resources. The following headings provide these data together with the locations where they were found.

2.2.1 Land use data

Six satellite imageries from 1995, 2000, 2005, 2010, 2015, and 2020 were utilized in the study to analyze the change in urbanization. The satellite imageries of the years 1995–2015 were taken from Google Earth. Since the satellite image of 2020 is not available on Google Earth, the Landsat-8 OLI/TIRS-C1 Level-1 satellite image from USGS Earth Explorer was used. Google Earth and USGS Earth Explorer provide free satellite imageries to researchers globally. While the spatial resolution of the satellites taken from Google Earth is 10 m, the spatial resolution of the image taken from the Landsat satellite is 30 m. In order to avoid data loss in satellite imageries, the cloud coverage was taken as 0%.

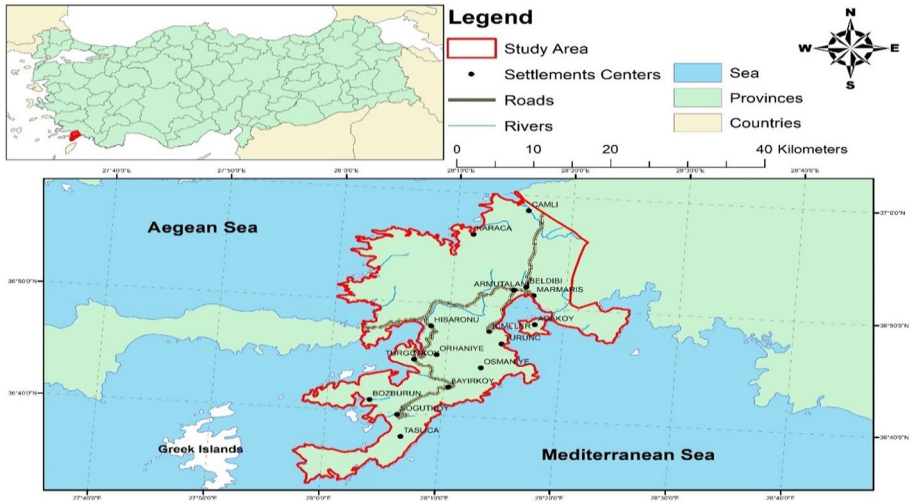


Fig. 1 The location and placement of Marmaris in Türkiye

In ArcGIS 10.4.1, a Geographic Information Systems (GIS) program, the provided satellite imagery were geo-referenced according to their coordinates (UTM 35 N Zone) and clipped according to the study area limits. According to the method outlined in the Method section, satellite pictures were prepared for analyzing the increase in urbanization.

2.2.2 Population data

The winter population data for Marmaris from 2007 to 2019 were gathered from the Turkish Statistical Institute (TSI) to demonstrate the relationship between population increase and urbanization in the region (TSI, 2020). Population data of domestic tourists coming to the region was obtained from the Republic of Türkiye Ministry of Culture and Tourism for the years 2002–2020 (Republic of Türkiye Ministry of Culture and Tourism, 2020). At the same time, since daily visitor data is not available, 10% of local tourists were considered daily visitors and assumed to arrive during peak summer (4 months) as suggested by some studies (Unur & Erdem, 2004; Republic of Türkiye Ministry of Culture and Tourism, 2017). The reason for this is the household domestic tourism statistics published by the (TSI, 2021). According to statistics, in the first quarter of 2021, the ratio of domestic visitors, day visits to overnight stays was 11%. In the second, third, and fourth quarters of 2021, this figure was 10%, 7%, and 11%, respectively. This shows that the ratio of daily visits to overnight stays of domestic visitors is approximately 10% in 2021. Based on these data, 10% of the overnight stays of domestic visitors were accepted as daily visitors. The number of overnight stays of foreign tourists was obtained from the data from 2002 to 2019. Due to the COVID-19 epidemic that affected the whole world in 2020, 2020–2021 data was not taken into account.

2.2.3 Drinking and utility water data

Marmaris supplies its drinking and utility water from Marmaris Dam. Marmaris Dam serves multiple purposes, including drinking and utility water, irrigation, and flood control.

The dam was built as a concrete-faced rockfill dam (Kaya, 2008). Marmaris Dam, whose construction began in 1998, began to serve in 2006. While the reservoir volume of the dam is 30 hm³, the amount allocated for drinking and utility water is 22.39 hm³/year. Approximately 78% of the dam’s water is used for drinking and utility water, while 22% is used for irrigation. (Republic of Türkiye Ministry of Environment and Urbanisation, 2018). In this study, analyses will be carried out by taking the volume of water withdrawn for drinking and utility water as a reference.

2.3 Methods

In this study, water demand has been evaluated according to population growth. At the same time, the relationship between land use and urbanization has been revealed, and Fig. 2. depicts the flow chart for the method used in the study.

2.3.1 Supervised classification method

The sample regions that specify the earth’s features are used to build files with defined spectral features for the places to be categorized in this approach. Each pixel is allocated to one of the classes determined by the estimated probability value when picture data is applied to these files (Aliyazıcıoğlu, 2019). The maximum likelihood technique was used to apply the supervised classification model. To estimate probabilities and take into account the variety of brightness values within each class, this classification employs the training data to estimate the means and variances of the classes. Based on Bayesian probability theory, this classifier. When accurate training data is made available, it is one of the most effective classification methods and algorithms (Abbas & Jaber, 2020; Perumal & Bhaskaran, 2010). The precise estimation of the mean vector and covariance matrix for each spectral class is critical to the maximum likelihood classification method’s performance. In this study, land use and land cover (LULC) classes were determined according to three different classes: forest, bare area, and residential area.

For the satellite imageries taken in 1995, 2000, 2005, 2010, 2015, and 2020, a separate controlled categorization was produced using the LULC classifications listed in Table 2. These operations were performed with the help of ArcGIS 10.4.1 software. As a result of the classifications made, the areas covered by each LULC class were calculated according to the specified years. In this way, changes in land use in Marmaris were determined.

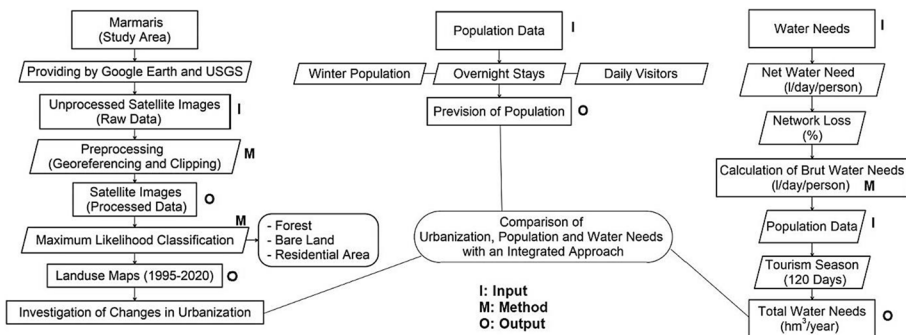


Fig. 2 Flowchart depicting the study’s process

2.3.2 Population projection method

Change in a population occurs continuously, not at annual intervals as in geometric increase. The fact that population growth occurs at all points in time is best expressed in exponential growth. The exponential regression method, which was also used in this study, has been used in many studies to determine the increases in the population (Xu et al., 2019; Khodabin et al., 2012). The population projections for Marmaris every 5 years until 2060 were made with this method. In this method, the exponential growth rate is first calculated according to the winter population data between 2007 and 2019 using the equation below (Eq. 1).

$$r = \frac{\ln\left(\frac{N}{N_0}\right)}{t} \quad (1)$$

After calculating the exponential growth rate, the population projection for the desired year is calculated according to Eq. 2.

$$N = N_0 e^{rt} \quad (2)$$

The parameters in these equations are,

r = exponential growth rate,

N = population at the end of the period,

N_0 = population at the beginning of the period,

t = It is the time interval between two populations.

2.3.3 Water need

In order to determine the amount of water needed annually, the gross water need per capita should be calculated. In order to calculate this, the amount of net water needed per capita (per capita water consumption) and network losses should be taken into account. Gross water needs are calculated according to Eq. 3.

$$Q_b = Q_n (1 + L_n/100) \quad (3)$$

The parameters in these equations are,

Q_n = Net water need (l/person/day),

Q_b = Gross water need (l/person/day)

L_n = Network loss (%)

After calculating the gross needs, the total water needs are calculated with the following Eq. 4.

$$Q_T = [(Q_b/1000) \times N_g \times T]/1000 \quad (4)$$

The parameters in these equations are,

Q_T = Total water need (hm³/year),

Q_b = Gross water need (l/person/day)

N_g = Population data (number of people: winter, overnight stays and daily visitors)

T = Time (day)

3 Results

3.1 Changes in landuse and urbanization

The research region was analyzed after the satellite imageries were divided into three main land use types (forest, bare land, and residential). The change in land use between 1995 and 2020, in 5 year periods, shows that urbanization has increased rapidly in the region. The land use maps for the years 1995–2020 with 5 year periods are shown in Fig. 3 according to the supervised classification.

When looking at Fig. 3, the first thing that stands out is that the red colored residential regions increased steadily from 1995 to 2020. It has been noted that the bare area depicted in yellow has given way to residential development. On the other hand, it was observed that there was a relatively lower rate of decrease in forest lands compared to bare lands. However, the forest lands of the region were severely damaged in the forest fires that lasted for 8 days on July 8, 2021 (Bayazıt & Koç, 2022). Since the pixel dimensions of the raster maps given in Fig. 4 are known, it is possible to calculate the areal magnitudes of the land change in the years examined. The area of a pixel with a side size of 10 m was multiplied by the number of pixels of the relevant land class to calculate how much area it covers. The changes in land change in terms of areal magnitudes between the years 1995 and 2020 is depicted in the graphs in Fig. 4.

Figure 4 shows that forest lands in Marmaris have reduced by 6.15% since 2000, covering 18,698.49 ha in 2020. It has been observed that bare lands have decreased by 18.28% in the 25 years examined and covered an area of 46,407.96 hectares in 2020. Contrary to the forest and bare land, an increase was observed in residential areas in Marmaris. The residential areas, which covered only 3.31% of Marmaris with an area of 2,627.98 hectares in 1995, were seen to cover 17.97% by 2020 with an area of 14,259.24 hectares. This situation reveals that the area covered by urbanization in the study area has increased by 14.66%. This striking change in land use shows that the region is in a rapid urbanization. This situation increases the pressure on the limited water resources of the region. In such a case, conscious use of water in cities, new urban planning and design approaches and policies to prevent this problem are important.

3.2 Population and tourism data projection

The population prediction estimates there will be 116,941 people living in the Marmaris district overall in 2060. This population represents the local population living in the region in summer and winter. Therefore, it should be considered that this number will be significantly higher given the region's tourism potential. With the equation obtained according to the regression analysis of the number of overnight stays between 2002 and 2019, projections were made in 5 year periods between 2020 and 2060. For this reason, it has been observed that the increasing trend will continue between 2020 and 2060. In the overnight projection, it has been determined that 14,330,010 overnight stays will occur throughout the year in 2060 (Fig. 5). There is a 65% decrease in overnight stays in 2020 compared to the previous year. This is thought to be due to COVID-19 restrictions. As can be seen from Fig. 5, one of the sectors most affected by the COVID-19 bans is the tourism sector. It is seen that the rate of increase in overnight accommodation is much higher than the winter population. This situation shows that the impact of tourism populations should not be

ignored in the research of the adequacy and sustainability of water resources in a tourism city.

3.3 Urbanization and population

The previous sections revealed the increase in urbanization with the change in land use and the increase in population with the calculated population projections (Fig. 5). In this section, the relationship between these two parameters is examined. In Fig. 6, the relationship between population and urbanization in Marmaris in the years 2010–2060 is shown.

When the graph given above is examined, it is seen that while the winter population of Marmaris was 67,633 in 2010, there was a residential area of 7,325.87 ha in the same year. This means that the residential area per capita in 2010 was 1,083.18 m². With the projections made, it has been calculated that the winter population of Marmaris in 2060 is 116,941, and the expected residential area is 184,983.97 ha. In this case, it is seen that the residential area per capita in 2060 is 15,818.57 m². According to this data, unplanned urbanization is observed in the study area. As a result of the analysis, it is revealed that the increase in urbanization is much higher than the increase in population. This situation reveals the fact that the resident population in the region is low, but since the region is an important region for summer and sea tourism, many people have a summer house, even if they are not officially residents. Therefore, it is more logical to evaluate the high rate of increase in residential areas together with the resident population and tourism population. In addition, when the relationship between the winter population and residential areas is examined, there is a logarithmic relationship. The R² value of the relationship was found to be 0.99. This confirms that, as expected, urbanization and population are in a strong statistical relationship.

3.4 Populations and water needs

With the increase in the population, water scarcity has become a general and current problem. (Chouchane et al., 2018; Xu et al., 2021). In addition to population growth, in tourism regions such as Marmaris, where seasonal population fluctuations are evident, the management of water resources gains more importance with the intense increase in water demand in the summer months.

In this study, the population projections (winter and tourism) of Marmaris, which is one of the important tourism regions in Türkiye, until 2060 were determined, and how long the existing water resources would be sufficient for the region, as well as the relationship between urbanization and population change, were examined. It has been revealed that the rate of urbanization is faster than the rate of population growth (Fig. 5). Considering the hydrological changes that this will bring, water resources planning should be done in this context.

The water needs of the projected winter population were determined by using Eq. 4 (Table 1). The per capita water consumption of the winter population has been determined as 250 l/day for the years 2010–2020, 260 l/day for 2025–2035, 270 l/day for 2040–2050, and 280 l/day for the years 2055–2060, respectively. If current consumption habits continue, the expected per capita water consumption after 2030 is 270 l/day. Between 2010 and 2020, the network losses are taken as 40%, which is the current network loss (Muğla Metropolitan Municipality, 2021), and it is assumed that the network losses for other years have decreased to 30% with possible improvements. It is stated that local municipalities

Table 1 Water needs for winter populations in Marmaris by years

Year	Net water need (l/day/person)	Network Loss (%)	Population	Gross water need (l/day/person)	Total gross water need of the winter population (hm ³ /year)
2010	250	40	67,633	350	8.64
2015	250	40	75,053	350	9.59
2020	250	40	80,004	350	10.22
2025	260	30	83,892	338	10.35
2030	260	30	87,968	338	10.85
2035	260	30	92,243	338	11.38
2040	270	30	96,725	351	12.39
2045	270	30	101,425	351	12.99
2050	270	30	106,354	351	13.63
2055	280	30	111,522	364	14.82
2060	280	30	116,941	364	15.54

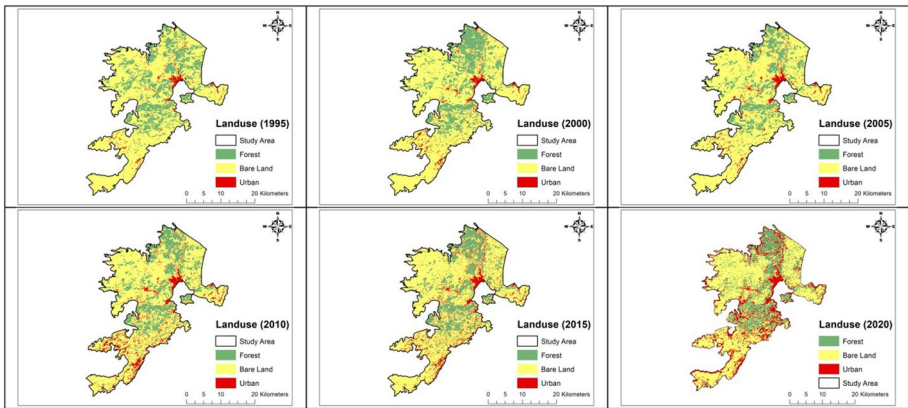


Fig. 3 Change in land use in the study area in 25 years (1995–2020)

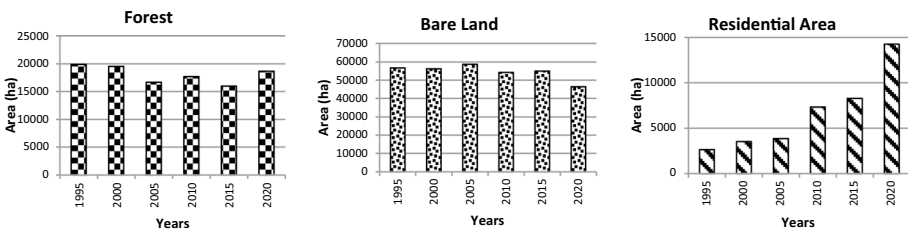


Fig. 4 Changes of land use classes over the years

should reduce their water loss rates to a maximum of 30% in the Regulation on the Control of Water Loss in Drinking Water Supply and Distribution Systems of the Turkish Ministry of Forestry and Water Affairs (Republic of Türkiye Ministry of Agriculture and Forest, 2021).

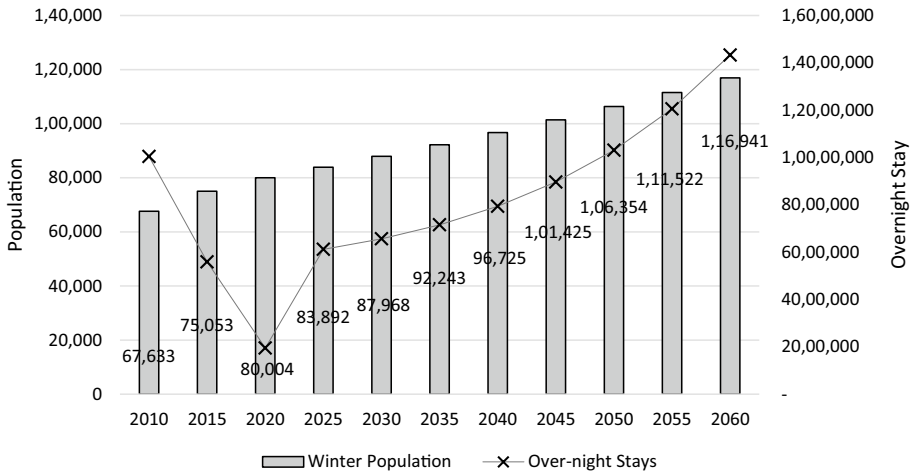


Fig. 5 Winter population and overnight stay projections of Marmaris between the years 2010–2060

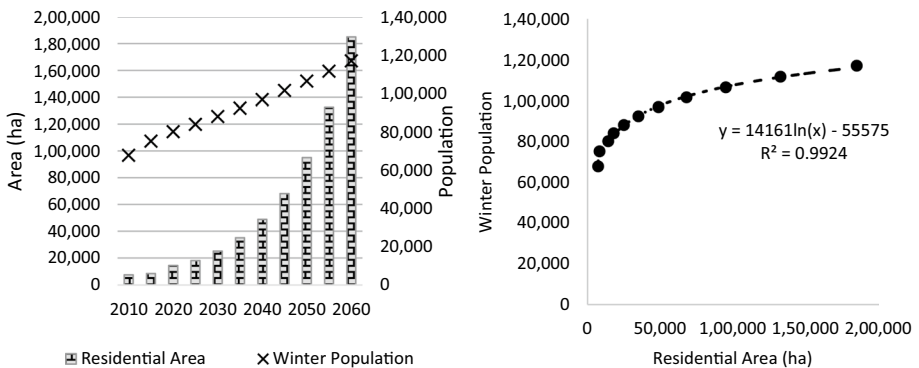


Fig. 6 The population-urbanization relationship in the study area from 2010 to 2060

In 2060, it has been determined that there will be an increase of almost 80% in the water needs of the winter population compared to 2010 (Table 1). The relationship between the determined water needs and the winter population has been revealed (Fig. 7).

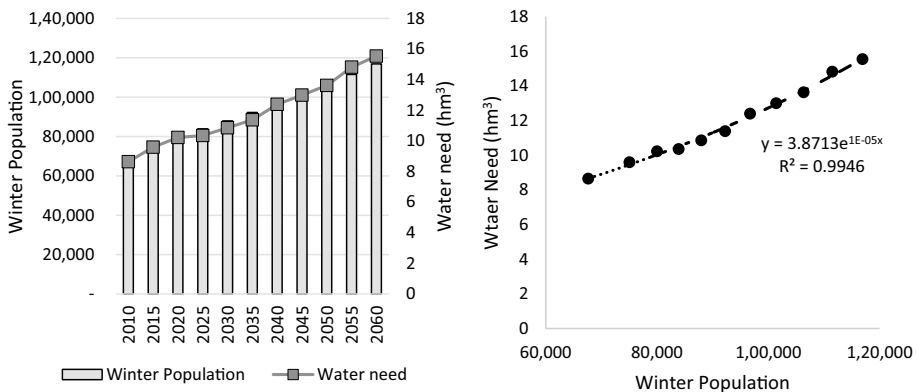
To keep the water need, which is supplied from limited resources and is directly related to the population, at a minimum level, it is necessary to reduce the loss of network and water consumption per capita (Spedaletti et al., 2022; Hu et al., 2021).

While calculating the water needs of the overnight population, the per capita water consumption was accepted as 380 l/day. In a study, the amount of water consumed by tourists in Türkiye was stated as 400 l/day (Gössling et al., 2012). Network losses are the values used to calculate the water needs of the winter population. While the water needs of the overnight stays are given in Table 2, the relationship between water needs and the population is given in Fig. 8.

Table 2 shows the increase in water needs depending on the population, despite the decrease in network loss.

Table 2 Water needs for overnight stays in Marmaris by years

Year	Net water need (l/day/person)	Network loss (%)	Overnight Stay	Gross water need (l/day/person)	Total gross water need of the overnight stay population (hm^3/year)
2010	380	40	10,043,448	532	5.34
2015	380	40	5,591,913	532	2.97
2020	380	40	1,951,659	532	1.04
2025	380	30	6,119,184	494	3.02
2030	380	30	6,564,424	494	3.24
2035	380	30	7,156,851	494	3.54
2040	380	30	7,938,980	494	3.92
2045	380	30	8,965,675	494	4.43
2050	380	30	10,307,739	494	5.09
2055	380	30	12,056,545	494	5.96
2060	380	30	14,330,010	494	7.08

**Fig. 7** Relationship between the winter population and the water needs of Marmaris

Apart from the population given, because Marmaris is a tourism region, many daily visitors come to Marmaris, especially in the summer months. Since it is not possible to reach any data on this population, the number of daily visitors has been accepted as 10% of domestic overnight stays. The calculation was made assuming that daily visitors come during the summer months (June, July, August, and September) and water consumption is 70 l/day per person. Thus, the effect of daily visitors on the water needs is also included in the calculations. The water needs of daily visitors are given in Table 3.

The water needs of the daily visitor, overnight, and winter populations were determined. According to the analyzes made, water needs were calculated according to the individual population data (daily, overnight and winter). However, since Marmaris is an important city in summer tourism, it would be correct to consider water needs together with all population data. In this way, the total water need of Marmaris was determined (Fig. 9). The annual total water needs, which was 10.22 hm^3 in 2020, is expected to increase approximately 3 times to 33.91 hm^3 in 2060. In 2060, there would be a 15.54

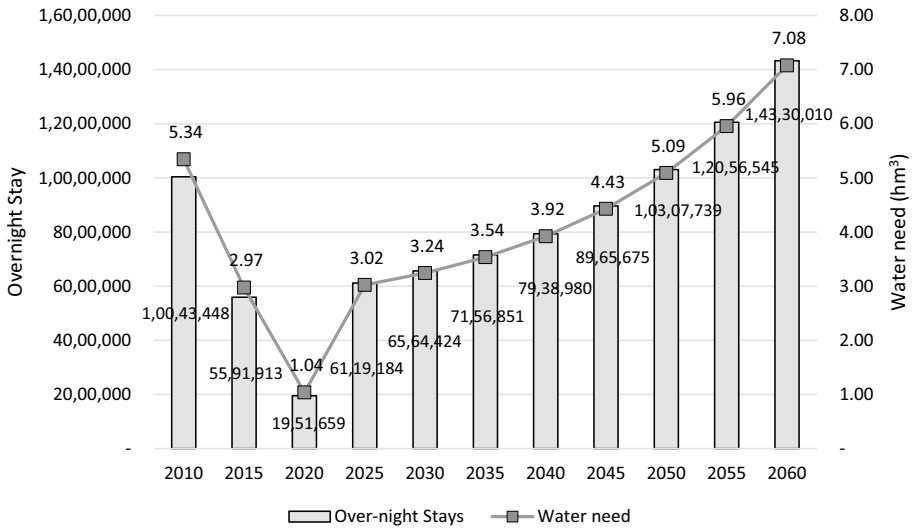


Fig. 8 Relationship between the overnight stay and the water needs of Marmaris

Table 3 Water needs of daily visitors in Marmaris by years

Year	Net water need (l/day/person)	Network loss (%)	Daily visitor	Gross water need (l/day/person)	Total gross water need of the daily visitors (hm ³ /year)
2010	70	40	92,997	98	1.09
2015	70	40	118,436	98	1.39
2020	70	40	86,228	98	0.01
2025	70	30	173,525	91	1.89
2030	70	30	223,928	91	2.45
2035	70	30	288,970	91	3.16
2040	70	30	372,905	91	4.07
2045	70	30	481,220	91	5.25
2050	70	30	620,996	91	6.78
2055	70	30	801,371	91	8.75
2060	70	30	1,034,139	91	11.29

hm³ annual water needs if the tourist populations were not taken into consideration in the population estimates of the city’s residents. It has been established how tourism affects the city’s water requirements. In the figure, the tourism population (overnight stays and daily visitors) has decreased with the COVID-19 shutdowns in 2020. This situation caused a decrease in the total water requirement in 2020.

The current water potential of Marmaris was stated as 22.39 hm³ in the study. By 2019, the Marmaris Dam’s occupancy rate has dropped by 15–93.75%. This situation highlights how climate change is affecting water resources. By associating the current

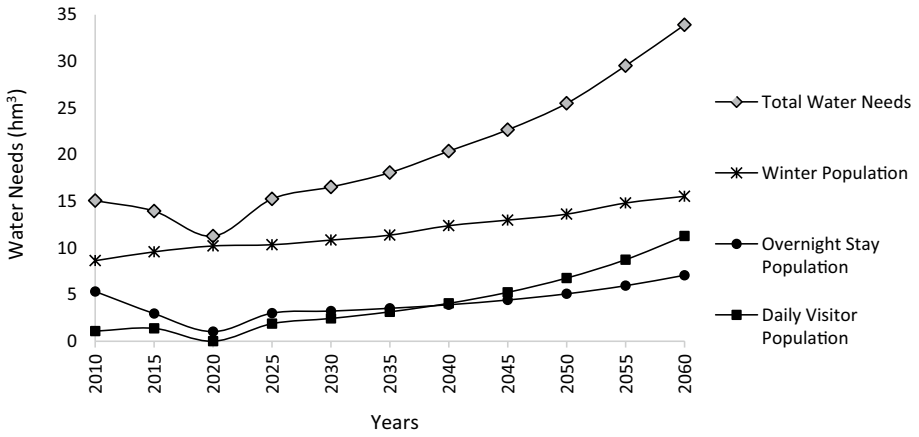


Fig. 9 Water needs according to different population projections

water potential with the water needs over the years, it has been determined how long the water resources will be sufficient for the district (Fig. 10).

As a result of the analysis made, it has been determined that the current water resources of Marmaris will be sufficient until 2045. After 2045, it will be necessary to either increase the water resources, reduce the network losses to very low levels, or reduce the water consumption so that the region does not experience a water problem. Especially considering that Marmaris is a tourism city, it is thought that local decision makers should take urgent actions and ensure the sustainability of usable water.

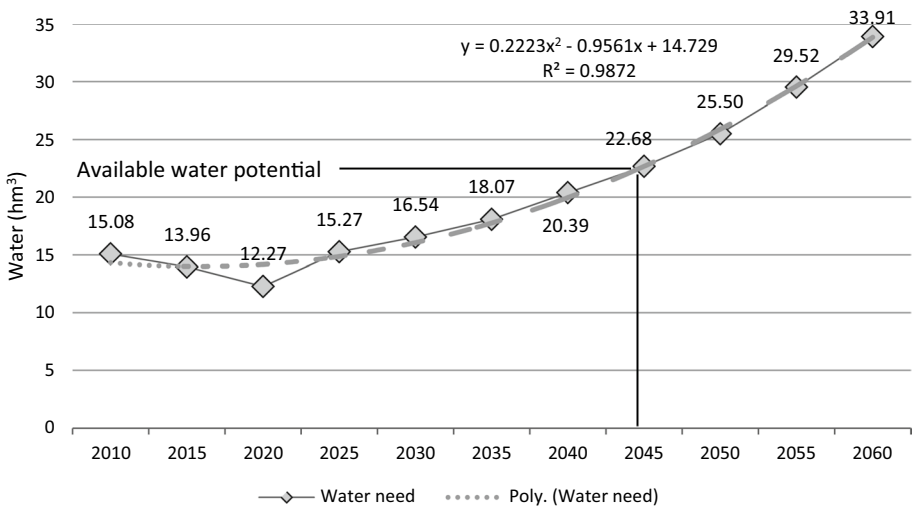


Fig. 10 Total water needs of Marmaris between 2010–2060, and the potential of current water resources

4 Discussions

In this study, the adequacy of domestic water resources in Marmaris, which is a tourism region, was examined. While doing this, population data, water consumption data, and network losses were obtained from the relevant institutions and projected. The exponential increase method used in population and water consumption projections has also been used in different studies (Koç et al., 2020). Thus, a new example was added to the literature. However, there are different methods used in the literature for population projection (Jing et al., 2020; Neumann et al., 2015). At the same time, although the network losses are obtained from the available data in this study, studies have also been carried out to determine the network losses (Al-Washali et al., 2020; Petroulias et al., 2016; Ananda, 2019; Mutikanga et al., 2009).

The water consumption of the tourism sector varies regionally and is not known exactly. Therefore, the water consumption of tourists is not known exactly (Gössling et al., 2012). In many studies, it has been stated that the daily water consumption per person for overnight accommodation varies according to the tourism region and the type of accommodation (Pensiri et al., 2016; Perez et al., 2020; Tirado et al., 2019). In this study, water consumption for overnight stays was accepted as 380 l/per capita/day, considering the literature. It can be deduced that the amount of consumption may be more or less in different studies, but it is a common belief that the consumption amount is affected by the hotel category (Tortella & Tirado, 2011; Hof & Schmitt, 2011; Gössling et al., 2012). Therefore, in this study, different water consumptions could be taken into account by categorizing the hotels belonging to the study area. New researchers can do a more comprehensive study by taking this into account.

The change in land uses over the years (1995–2020) clearly shows that urbanization is increasing rapidly. This situation puts pressure on the water resources of the region. Urbanization negatively affects surface waters and groundwater. The rapid increase in urbanization causes the depletion of surface waters and groundwater. Groundwater resources are also adversely affected, as the increase in artificial surfaces due to changing land use with urbanization reduces infiltration (Wakode et al., 2018). Especially the agricultural lands in Marmaris region benefit from groundwater. However, in this study, the adequacy of urban water was investigated. Urbanization and population growth are two phenomena that cannot be considered separately. There is a direct proportional relationship between urbanization and population growth (Özür, 2016). In a study dealing with the years 1960–2017, the increasing temperature and evaporation in Marmaris, as well as the increase in the total domestic and tourism population, showed that the pressures on water resources will continue to increase (Şensoy et al., 2019). In this study, the water resources of the study area were considered constant in the analysis, and climate change and changes in annual precipitation were not taken into account. However, different studies have revealed the effects of climate change on water resources (Lu et al., 2019; Gosling & Arnell, 2016; Liu et al., 2017). A more comprehensive study and more accurate results can be obtained by integrating this study with studies on the impact of climate change on water resources.

This and similar studies play an important role in tackling the global water scarcity problem. According to the “Tourism for Development” report published by the United Nations World Tourism Organization (UNWTO) in 2017, although the tourism sector seems to have a small share in water consumption, it has a large impact on freshwater resources in countries such as Spain, Bali and Indonesia, which are at risk of water scarcity (World Tourism Organization, 2018). indicated that it can create pressure.

Considering that Türkiye is among the countries that may experience water scarcity in recent years, the pressure of the tourism sector on water resources should not be ignored. In Marmaris, which is an important tourism city in Turkey, the pressure of the tourism sector on water resources has been investigated and the research gap in this area has been filled. At the same time, this study has obtained important results for the authorities of the study area, but more detailed studies are needed. In this context, we hope that researchers will make new contributions to the literature by using this study as a reference.

5 Conclusion and recommendations

In addition to being the basic need of humans and all living things, water plays a vital role in many economic and social areas. Therefore, human beings need water to develop themselves and their environment. The efficient use of water obtained from limited resources is also important in terms of meeting the water needs of future generations. To use water more efficiently, reducing or preventing water losses and reducing water consumption are basic solutions. Many studies have been carried out in different areas to reduce water use (Aili et al., 2021; Alkaya & Demirer, 2015; Gunson et al., 2012). Unfortunately, serious water losses occur in the distribution networks used to deliver water to consumers. To conserve water and reduce the need for water, network losses must be reduced to minimum levels.

Unfortunately, water shortages are expected in many parts of the world in the coming years. (Moya-Fernández et al., 2021). According to the future projections of Türkiye, it is estimated that “quite high-water scarcity” will be classified among the nations in 2040 (Daily Sabah, 2021). Considering that the problem of water scarcity is becoming more and more widespread globally and regionally, the planning and management of water resources have become much more important. Many studies have proposed solutions to water scarcity that may occur in the future (He et al., 2021; Tzanakakis et al., 2020; Jia et al., 2020; Zhang et al., 2021). However, more comprehensive studies and more awareness are still needed. In an column written for one of the local newspapers, it was said that Marmaris and the surrounding area, which already has a water shortage, could experience serious water crises in the future if necessary precautions are not taken (Atabey, 2019). In regions such as Marmaris where tourism is intense, meeting the water needs of the tourism sector is also important for the economy of the region. Therefore, there is a strong link between regional economic development and the sustainability of both water resources and tourism. Ensuring the sustainability of tourism and its development in this concept; conceptually, it means preserving and developing the regional or local cultural and natural values that constitute the source of tourism and ensuring the continuation of their attractiveness. Sustainable Tourism is meeting the needs of tourists and local people without compromising the needs of future generations. Sustainable tourism is a form of production in which environmental values, society and culture are carried out and managed as beneficiaries, not victims of developing tourism (Çakır & Çakır, 2010; Kahraman & Türkay, 2006). For sustainability, it is inevitable to make the right planning. In order to achieve this, the South Aegean Development Agency (SADA), which has goals such as the efficient and effective use of resources, carries out various studies and plans (SADA, 2014).

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