Kacikoc, M. Dadaser-Celik, F., (2025), The impact of agricultural intensification and water abstraction in a Mediterranean watershed, pp. 136-141. In Gastescu, P., Bretcan, P. (edit., 2025), Water resources and wetlands, *7th International Hybrid Conference Water resources and wetlands, 10-14 September 2025, Tulcea (Romania)*. Available online at http://www.limnology.ro/wrw2025/proceedings.html

7th International Hybrid Conference Water resources and wetlands, 10-14 September 2025, Tulcea (Romania)

THE IMPACT OF AGRICULTURAL INTENSIFICATION AND WATER ABSTRACTION IN A MEDITERRANEAN WATERSHED

Meltem KACIKOC[1], Filiz DADASER-CELIK[2]

[1] Department of Environmental Engineering, Suleyman Demirel University, Isparta, Türkiye, Email: meltemkacikoc@sdu.edu.tr

[2] Department of Environmental Engineering, Erciyes University, Kayseri, Türkiye, Email: fdadaser@erciyes.edu.tr

Abstract. Egirdir Lake, located in the Mediterranean region of Türkiye, is one of the most important freshwater ecosystems in the area. It supports many vital functions such as drinking water supply, irrigation, and aquaculture support. However, its ecological condition is increasingly threatened by anthropogenic pressures. The most significant of these are excessive water withdrawals for irrigation, primarily due to the dominance of high-water-demand fruit farming in the basin, and nutrient inputs from diffuse agricultural runoff and untreated wastewater. Like many shallow lakes in the semi-arid Mediterranean climatic region, Egirdir Lake is highly vulnerable to hydrological stress. The integrated effects of climate change and unsustainable land and water use have led to a continuous decline in water levels and degradation of ecological conditions. Early indications suggest shifting from a clear-water, macrophyte-dominated system to a more turbid, algae-dominated state. Once this regime shift begins, it is often difficult to reverse. Egirdir Lake represents various Mediterranean inland waters, where the conflict between agricultural production and ecological protection is particularly intense. The pressures observed in the lake basin create the need for integrated watershed management and application of sustainable agricultural and water use practices. They are critical for protecting the ecological health of Egirdir Lake and for maintaining its resilience to climate change.
Keywords*:* Egirdir Lake, water level decline, water quality degradation, anthropogenic impacts, climate change, ecological stress

1 INTRODUCTION

Egirdir Lake, located in the Mediterranean region of Türkiye, is one of the largest freshwater lakes (Figure 1). It is essential to the region's water supply and supports various ecosystem services, including drinking water provision, agricultural irrigation, and sustaining fisheries. Being a shallow lake in a semi-arid climate, Egirdir Lake is naturally sensitive to both human pressures and climatic fluctuations.

The drainage area of the Egirdir Lake covers 3430 km², and its surface area is approximately 460 km². The lake's water depth changes between 7 m and 13 m (Yerli et al., 2013). The climate in the basin is continental with annual precipitation of 598 mm and an annual average temperature of 12 °C. Water inflows to the lake occur by precipitation, surface flows, and groundwater flows. The primary streams feeding the lake are Hoyran (A.Tırtar) Stream, Çay Stream, Gelendost Stream, and Pupa Stream. Diversion from the Köprüçay Lower Basin also transfers water to the lake. Water losses from the lake are due to evaporation and water use for irrigation. The Boğazova, Hoyran, Barla,

Gelendost, Senirkent, and Atabey Plains irrigation schemes (located within the Burdur Lake Basin boundaries) are irrigated with water from Egirdir Lake. Additionally, there are dams, ponds, and reservoirs operated by State Hydraulic Works (DSI) for irrigation purposes within the lake's drainage area (Uluborlu Reservoir, Kurusarı Reservoir, Sücüllü Reservoir). Water from Egirdir Lake is also withdrawn for drinking water purposes.

In recent years, the lake has been threatened by increasing pressures, mainly caused by excessive water withdrawals, agricultural intensification, and climate change (Kacikoc et al., 2025). Large amounts of nutrients are transported to the lake from agricultural areas. Together with declining water levels (Figure 2), this has caused water quality degradation and led to an increase in the risk of a regime shift toward a more turbid and algae-dominated system. These pressures have also raised concerns about the lake's sustainability. This study aims to evaluate the threats to Egirdir Lake and addresses the need for integrated water resource management under the combined pressures of climate change and human activity.

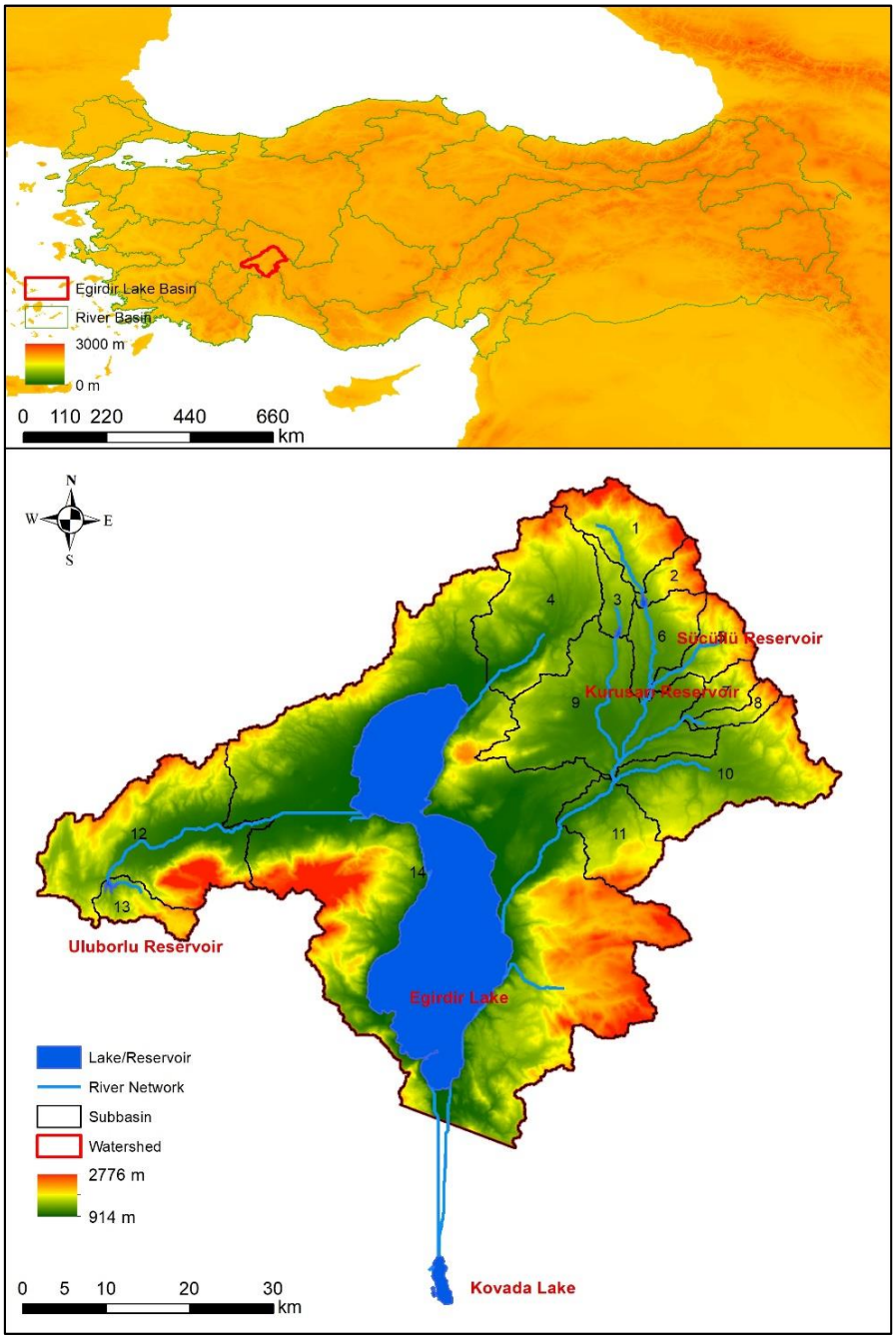

Figure 1. Egirdir Lake Basin

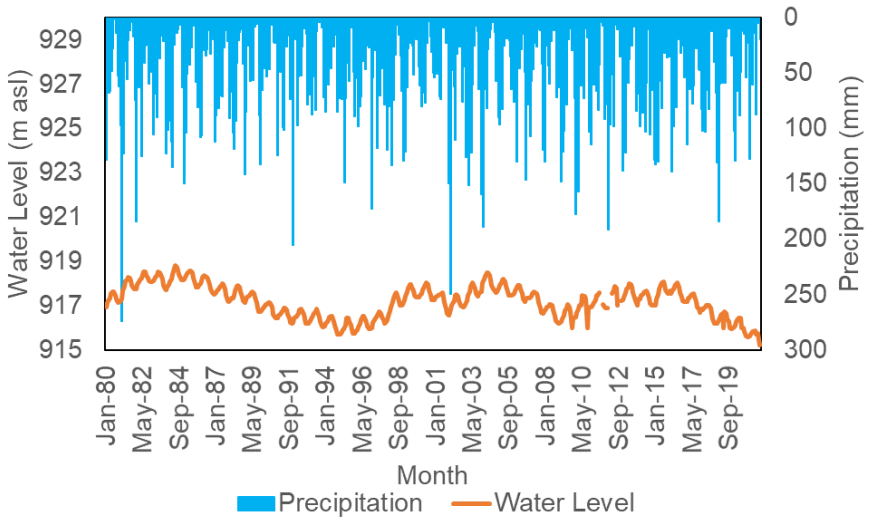

Figure 2. Water levels and precipitation at the Egirdir Lake during the 1980-2021 period

2 PRESSURES ON EGIRDIR LAKE

Egirdir Lake is under pressure from various sources caused by anthropogenic and environmental factors. The most critical threat to Egirdir Lake is the intensification of irrigated agriculture in its catchment. The Egirdir Lake Basin already has several reservoirs built for irrigation purposes. These reservoirs control the flows to Egirdir Lake. Fruit farming, which requires large amounts of water, has increased in the basin recently, with water availability from these reservoirs. There is also water abstraction directly from the lake to irrigate areas downstream. Both the reservoirs in the catchment and the uncontrolled water abstraction for irrigation cause the lake's water levels to drop substantially during summer months, during periods of high irrigation. Figure 3 shows the estimated monthly water withdrawals from Egirdir Lake during the 1980-2021 period. We notice a clear seasonal pattern, with peaks in the summer months, due to increased irrigation. We also notice that water withdrawal has steadily increased from 1980 to 2021. The increase was gradual until the 2000s, but accelerated afterwards. The amount of water withdrawn during peak periods has risen more than seven times.

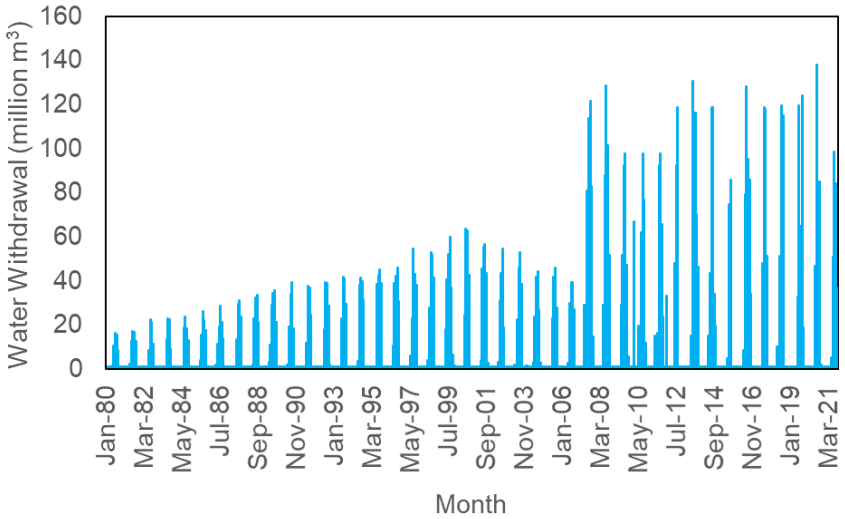

Figure 3. Water withdrawals from Egirdir Lake during the 1980-2021 period

Agricultural activities stand out not only due to their water consumption but also because of the pollutant loads they generate. These activities contribute to water pollution through nutrients such as nitrogen and phosphorus, pesticides, erosion-induced sediments, bacteria, and heavy metals (Zahoor and Mushta, 2023). High nutrient concentrations trigger phytoplankton growth, leading to

harmful algal blooms, which can cause oxygen depletion, ecosystem degradation, and toxin production, posing risks to both human and animal health (Lan et al., 2024). Pesticide residues, on the other hand, cause poisoning in aquatic organisms, disrupt ecosystem health, and lead to a decline in biodiversity (Onyango et al., 2024). Fertilizer and pesticide use in agriculture is significant in the basin (SGYM, 2024), which eventually ends up at the Egirdir Lake through transport by surface runoff and subsurface flows. There are also discharges of untreated or insufficiently treated wastewater from settlements around the lake. The most recent water quality data for Egirdir Lake is available from April 2025. At seven sampling stations distributed over the lake, the Secchi depth changed between 0.1 m and 0.5 m, and the average was 0.30 m. Chlorophyll-a concentrations were in the range of 6.32-33.05 mg/m^3 with an average of 13.86 mg/m^3. The average total nitrogen (TN) concentration was determined to be 0.88 mg/L (in the range of 0.72-1.48 mg/L), and the average total phosphorus (TP) concentration was 0.058 mg/L (in the range of 0.044-0.068 mg/L). Based on these data, the trophic status index ranged between 58.03 and 71.51, with an average of 62.17. This result suggests that the lake is in an eutrophic state.

The effects of anthropogenic pressures are intensified by increasing climate variability in the basin. Figure 4 presents annual precipitation, potential evapotranspiration, and average air temperature for the Egirdir Lake Basin from 1980 to 2020. We notice upward trends in potential evapotranspiration and air temperature at 2.02 mm/yr and 0.03°C/yr, respectively (Table 1). These trends were statistically significant at the 0.001 level. However, we also see an upward trend in precipitation at a rate of 0.88 mm/yr (Table 1). Although this trend is not statistically significant at the 0.001 level, it is still meaningful, showing that climatic influence was mostly from temperature increases rather than reductions in precipitation. As a shallow lake with a large surface area, Egirdir Lake is particularly sensitive to evaporation changes. Even small changes in this variable can potentially lead to lake-level fluctuations. Regarding lake levels, the trend is downward at a rate of 0.02 m/yr.

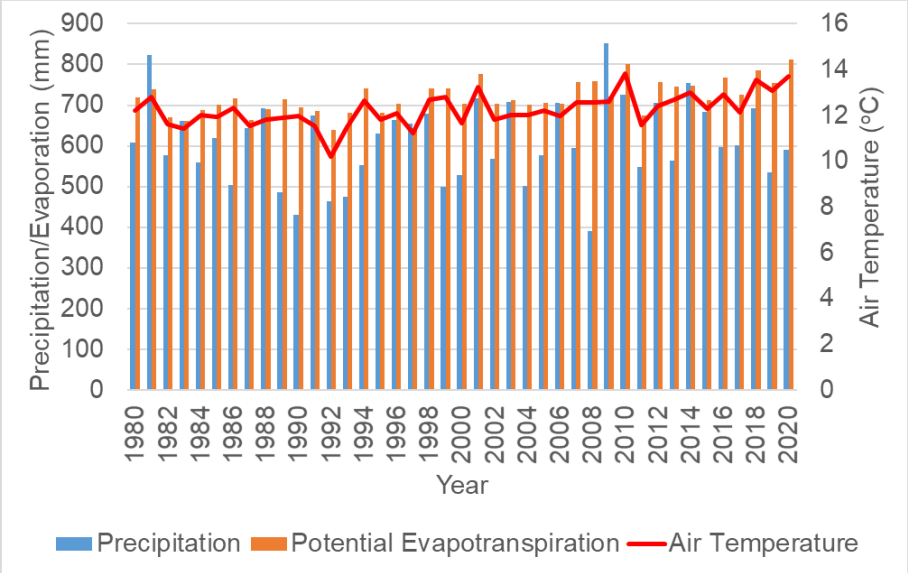

Figure 4. Precipitation, potential evapotranspiration, and air temperature at the Egirdir Lake Basin during the 1980-2021 period

Table 1. Trends in water levels and climatic variables

Variable	Slope	p-value
Water Level	-0.02 m/yr	0.05
Precipitation	0.88 mm/yr	0.52
Potential Evapotranspiration	2.02 mm/yr	0.00003
Air Temperature	0.03 °C/yr	0.00032

In shallow lakes, excessive drops in water levels increase sediment mobility, leading to elevated nutrient loads in the water column, reduced water transparency, and consequently, a deterioration in water quality (An et al., 2025). Moreover, water level fluctuations can negatively affect macrophyte communities in the lake, altering their composition and spatial distribution, which in turn disrupts the ecological balance (Foti et al., 2013; Liu et al., 2021). Rising temperatures further exacerbate these negative impacts by increasing water temperature, decreasing dissolved oxygen levels, and enhancing the biological availability of nutrients. In shallow and large-area lakes like Egirdir Lake, these effects are strongly felt; both as irregular water level fluctuations and as rising temperatures influencing the growth and spread of macrophytes, emerging as major factors threatening the ecological stability of the lake.

Agricultural intensification, excessive irrigation water withdrawals, and pollutant transport have caused ecological stress at Egirdir Lake. The decline in water level, which has been observed in recent years, is one of the significant outcomes of this stress. The increasing pressure from climatic variations may lead to further water quality degradation, disruption of aquatic habitats, and ecological changes in the lake ecosystem.

4 TOWARD INTEGRATED WATER RESOURCES MANAGEMENT AT EGIRDIR LAKE BASIN

Integrated water resources management (IWRM), in accordance with the EU Water Framework Directive, aims to achieve a condition that meets human water requirements while protecting natural ecosystems (Kalogiannidis et al., 2023; Koop et al., 2020). The long-term sustainability of Egirdir Lake depends on the implementation of a basin-wide IWRM strategy that reconciles ecological integrity with socioeconomic development. Considering the lake's role as a primary source for drinking water, irrigation, and fisheries, this strategy should focus on maintaining lake water levels, reducing pollution loads, and enhancing resilience to climatic variability.

In the context of Egirdir Lake, IWRM must address the overexploitation of water for irrigation, particularly in fruit-dominated agriculture and the corresponding hydrological alterations caused by upstream reservoirs and uncontrolled withdrawals. A regulated abstraction regime, based on real-time lake level monitoring and seasonal ecological thresholds, should be established. Furthermore, improving irrigation efficiency through drip and sprinkler systems can significantly reduce demand pressures.

Nutrient input reduction is another critical component. Establishing vegetative buffer zones, promoting organic farming, limiting fertilizer and pesticide use, and rehabilitating erosion-prone lands are essential to mitigate nonpoint source pollution. Additionally, strengthening wastewater treatment systems in surrounding settlements will help reduce the risk of untreated or insufficiently treated discharges that may reach the lake indirectly through surface and subsurface pathways.

An important factor for maintaining Egirdir Lake's function as a drinking water source is the health of its submerged macrophyte communities. These plants play a key role in stabilizing sediments, enhancing water clarity, and maintaining ecological balance. Rather than applying physical interventions such as mechanical removal, safeguarding macrophyte health should be achieved by restoring and stabilizing lake water levels. Ensuring a favorable hydrological regime will support macrophyte recovery, strengthen ecosystem resilience, and sustain the lake's capacity to provide clean water.

Management interventions should be participatory, involving local farmers, irrigation unions, fisheries cooperatives, and public institutions. Building a collaborative stakeholder platform will not only enhance compliance but also foster shared ownership of conservation efforts. Creating an IWRM strategy that consider the hydrological, ecological, and socioeconomic conditions of the Egirdir Lake Basin will provide the most effective approach toward long-term lake protection.

5 CONCLUSION

Egirdir Lake is facing increasing ecological stress due to agricultural intensification, excessive water abstraction, and climate change. Declining water levels and nutrient enrichment have increased the risk of eutrophication and ecological degradation. Protecting the lake's water quality and ecological functions, particularly its role as a drinking water source, requires basin-specific integrated management. Ensuring sustainable irrigation practices, regulating water use, reducing pollution loads, and maintaining healthy macrophyte communities through water level stabilization are essential for protecting the lake's future.

ACKNOWLEDGEMENTS

This study was supported by Erciyes University Research Fund (FBA-2024-14388).

REFERENCES

An, L., Liu, C., Fan, Z., Liao, K., Wang, W., & Wang, N. (2025). Effects of water level variations on the water quality of Huayang Lakes, China. Journal of Geographical Sciences, 35(1), 173-188.

Foti, R., del Jesus, M., Rinaldo, A., & Rodriguez-Iturbe, I. (2013). Signs of critical transition in the Everglades wetlands in response to climate and anthropogenic changes. *Proceedings of the National Academy of Sciences*, 110(16), 6296-6300.

Kacikoc, M., Mesta, B. Karaaslan, Y. (2025). Evaluating changes in water levels during normal flow and drought periods with a specific emphasis on water withdrawal, *Journal of Water and Climate Change*, 16 (3), 1073-1097.

Kalogiannidis, S., Kalfas, D., Giannarakis, G., & Paschalidou, M. (2023). Integration of water resources management strategies in land use planning towards environmental conservation. *Sustainability*, 15(21), 15242.

Koop, S. H., Grison, C., Eisenreich, S. J., Hofman, J., & van Leeuwen, K. (2022). Integrated water resources management in cities in the world: Global solutions. *Sustainable Cities and Society*, 86, 104137.

Lan, J., Liu, P., Hu, X., & Zhu, S. (2024). Harmful algal blooms in eutrophic marine environments: causes, monitoring, and treatment. *Water* 16: 2525.

Liu, Q., Liang, L., Yuan, X., Yan, S., Li, M., Li, S., ... & Li, C. (2021). Regulation of vegetation and evapotranspiration by water level fluctuation in shallow lakes. *Water*, 13(19), 2651.

Onyango, J., Kitaka, N., Van Bruggen, J. J. A., Irvine, K., & Simaika, J. (2024). Agricultural intensification in Lake Naivasha Catchment in Kenya and associated nutrients and pesticides pollution. *Scientific Reports*, 14(1), 18539.

SYGM (General Directorate of Water Management) (2024). Strategic Environmental Assessment Scoping Report of the Antalya River Basin Management Plan. *Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of Water Management, Ankara*.

Yerli, S.V., Alp, A., Yeğen, V.; Uysal, R., Yağcı, M. A., Balık, İ. (2013). Evaluation of the Ecological and Economical Results of the Introduced Alien Fish Species in Lake Egirdir, Turkey". *Turkish Journal of Fisheries and Aquatic Sciences*. 13 (5): 795-809.

Zahoor, I., & Mushtaq, A. (2023). Water pollution from agricultural activities: A critical global review. *Int. J. Chem. Biochem. Sci*, 23(1), 164-176.