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IMPACT OF SUSTAINABLE AGRICULTURAL PRACTICES COMPARED TO CONVENTIONAL AGRICULTURE ON THE BASIN AND ECOSYSTEM OF LAKE EGIRDIR

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Abstract: This project is based on 25 years of research and ongoing field studies conducted in the Lake Egirdir basin. Lake Egirdir, the second-largest freshwater lake in Turkiye, has been under increasing threat of ecological collapse in recent years due to a combination of challenges in maintaining the balance between conservation and utilization, as well as the growing impact of climate change. The declining water level of the lake has led to a significant reduction in water volume, which in turn has increased the concentration and ecological impact of pollutants in both the water column and bottom sediments. This process has severely compromised the ecological integrity of the lake. In order to ensure the recovery and sustainability of the lake, it is first and foremost, necessary to maintain the critical minimum water level and prevent further decline. In parallel, a transition from conventional to sustainable agricultural practices in the surrounding areas is considered essential not only for the restoration of the lake's internal ecosystem but also for the overall ecological resilience and sustainability of the entire basin.

Keywords: Ecological resilience, Lake ecology, Sustainable basin management

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1. Introduction

Agricultural pollution can be defined as the sum of activities that negatively affect the ecosystem and, as part of it, humans and their economic interests through the biotic and abiotic by-products resulting from various agricultural practices (Norman et al., 1997). In other words, agricultural wastes (both liquid and solid) originating from agricultural activities include surface runoff from pesticides, fertilizers, and production areas, erosion and dust resulting from tillage, animal manure and carcasses, crop residues, and all related waste materials (GEMET, 2025). Agricultural pollution may be a point source or a non-point source, depending on the type of origin. While point sources are relatively easy to control, non-point sources are more difficult, costly and continuous and require long-term and integrated management strategies. For this reason, the characteristics of the source must be carefully considered during the planning process. Abiotic sources of pollution are, as the term implies, of non-biological origin. These include pesticides, commercial fertilizers and by-products containing heavy metals. Biotic sources, on the other hand, refer to biologically derived (living-origin) by-products such as animal manure, biologically derived pesticides, other waste products originating from animal activities, and biological residues resulting from land management practices. To summaries, the primary pollutants in the aquatic environment from agricultural activities - whether biotic or abiotic – are nitrogen and phosphorus, the main nutrients for plant growth, together with pesticides used in agriculture, sediment transport caused by erosion, and fecal bacteria and viruses from animal waste.

One of the most current and important issues is the management of post-harvest stubble from cultivated lands. As in many countries, this issue is particularly important in rainfed rural areas in Turkiye. A study examining soils obtained from long-term field trials of stubble retention and removal, no-till, and conventional tillage showed that leaving or retaining stubble in the soil increased the availability of carbon sources and led to a higher abundance of genes favorable for metabolic activity and plant-pathogen interactions, but tillage practices did not affect the structure or diversity of the soil prokaryote community (Xu et al., 2025). The same study also reported that stubble addition or retention resulted in a significant increase in Proteobacteria but a decrease in Chloroflexi compared to the no-till condition (Xu et al., 2025). As a result, soil biota can constantly face processes such as reassigning dominant species based on carbon source availability. Numerous other studies have shown that leaving stubble in the soil has cumulative effects on improving soil ecology, promoting sustainable

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agricultural practices, and increasing plant yield (Ninkuu et al., 2025). One of the issues negatively impacting sustainable agriculture is wastewater from settlements (septic tanks, unregulated landfills, etc.), which requires separate consideration. It's important to note that wastewater from settlements, whether localized or distributed, contributes not only to nitrogen and phosphorus loads but also to the presence of hormone-disrupting preparations.

Another issue is that the use of surface irrigation techniques, known as basin, border, and furrow irrigation, instead of modern pressurized irrigation techniques, can lead to overuse of water, leading to depletion, enrichment of groundwater nitrate levels, erosion of valuable surface soil, and contamination by being carried to other surface water bodies.

As outlined above, agricultural activities can lead to a variety of complex and difficult to manage problems. In this context, if all agricultural practices are carried out with sustainable farming techniques, significant benefits can be realized for both nature and the people who depend most on these resources. Sustainable agriculture is defined by the American Society of Agronomy and adopted by the United States Government as follows: Sustainable agriculture is defined as a long-term agricultural approach that conserves and enhances the ecological integrity of natural resources, ensures stable production of food and fiber to meet human needs, the supports economic viability of producers, and fosters socio-environmental resilience in rural landscapes (Norman et al., 1997). Another concise definition is: agricultural production that is conducted with environmental responsibility and ensures that ecosystem functions are preserved and that future generations have access to secure food supply and a healthy quality of life (Robertson, 2015). As these definitions suggest, the core principle of sustainability is to maintain a long-term balance between conservation and utilization. Otherwise, acute problems may cause irreversible damage to both humans and the environment.

The main goal of sustainability is to protect the Earth's biodiversity and to safeguard the ecosystem services that functioning ecosystems provide for humanity. These are recognized as two fundamental goals of natural resource conservation (UMASS, 2025). The same principles also apply to sustainable agriculture. The sustainable agriculture ecosystem is associated with various terms such as agroecology, alternative agriculture, organic (biological, ecological) farming, low-input agriculture, integrated production, and regenerative agriculture (Aksoy and Yasar, 1994). The most appropriate form of sustainable agriculture depends on the specific characteristics of the area.

Sustainable agriculture is based on three main pillars (NSAC, 2025):

1. Environmental health
2. Economic profitability
3. Social and economic equity

The most important sub-components of each pillar are presented below.

1) Environmental health

i. Promotion of biodiversity

ii. Reduced use of agricultural inputs

iii. Protection of habitats

iv. Conservation of natural resources

v. Reducing the consumption of fossil fuels and chemicals

2) Economic profitability

i. Ensuring a living income for farmers and agricultural workers

ii. Emphasize direct marketing, cooperatives, alternative products, and local sourcing

iii. Supporting agricultural stakeholders through various incentive mechanisms where necessary

3) Social and economic equity

i. Continuous and effective knowledge sharing among communities

ii. Ensuring food security at the community level

iii. Reducing inequalities between communities by improving quality of life

When evaluating the relationship between the environment and energy, experts emphasize that the global agricultural industry must reduce its dependence on fossil fuels to meet the growing global demand for food (RNZ, 2025). This issue is directly related to sustainability and global climate change. Currently, the global food supply chain consumes nearly one-third of global energy and is responsible for more than 20% of global greenhouse gas emissions. The FAO estimates that by 2050, the world will need to produce 75% more food than today due to population growth and increased protein demand (RNZ, 2025). Whilst this may seem paradoxical at first glance, the main points listed above can be addressed through comprehensive and strategic planning first at an international level, and then by each country individually. Previous studies have shown that conventional agricultural methods have negative environmental and socio-economic side effects. These include loss of biodiversity, habitat destruction, deforestation, pollution of water, air and soil, salinization, desertification, depletion of water resources, loss of agricultural land, declining soil fertility, reduced nutritional value of agricultural products and decline in economic, social and cultural values (Hanson and Hendrickson, 2009). Many of these adverse effects are directly linked to the use of agrochemicals, which can increase agricultural productivity if used correctly. However, due to limited knowledge and lack of user training, the incorrect or excessive use of these chemicals can lead to significant environmental harm rather than the intended benefits. For instance, nitrogen, phosphorus, and potassium are essential for the production of crops used for food, feed, fiber, and biofuels. If used excessively, these nutrients can be lost to the environment through volatilization, leaching into groundwater, emissions into the atmosphere, or surface runoff. These nutrient losses can be minimized through the application of Best Management Practices

(BMPs), which improve nutrient availability to plants, enhance nutrient uptake efficiency, and better match nutrient application to agricultural needs (USDA, 2012). On the other hand, drought management is a serious challenge facing countries in the Mediterranean basin. According to many climates modeling studies, the impact of drought will become more pronounced as the mid-century approaches and will intensify further towards the end of the century. In this geography, crop production based on water, not plant, is considered inevitable. For the sustainability of agricultural production, transitions from irrigated to dryland farming in sensitive areas, as well as shifts to less water-intensive methods within irrigated production, will be inevitable.

This study is based on field observations conducted over the last 25 years and is complemented by recent research in Lake Egirdir. It also provides a comparative assessment of the potential benefits of sustainable agricultural practices over conventional methods, focusing on how these practices can contribute to the improvement of Lake Egirdir and its surrounding basin.

2. Materials and Methods

2.1. Study Area

Lake Egirdir is located in the Lakes District of Turkiye lies between 35°37′41″- 38°16′55″ north latitude and 30°44′39″ – 30°57′43″ east longitude (Figure 1).

The lake covers an area of 487.8 km^2 and has a catchment area of 3.309 km^2. It is of tectonic origin. The average depth of the lake is 6.5 meters, with a maximum depth of 15 meters near the settlement of Barla. At its maximum water level of 919.00 m, the lake has a volume of around 4.000 hm^3. The minimum operational level is 914.62 m.

This study examines the current agricultural structure in the Lake Egirdir basin. It evaluates how current agricultural production patterns and management practices could affect practices might shape the degradation of the basin in the future if they remain unchanged. Conversely, the study also assesses the long-term economic, social, and environmental benefits that can be achieved by transitioning to sustainable agricultural practices across the basin.

Figure 1. Lake Egirdir overview.

3. Results an Discussion

When examining the impact of climate change on the agricultural sector in the across major biogeographical regions of Europe, it is found that the Lake Egirdir basin is exposed to several significant risks: sharp increase in extreme temperatures, decrease in precipitation, heightened drought, loss of biodiversity, increased water demand in agriculture, lower crop yields, and increasing risks in livestock farming (EEA, 2019). Therefore, the effects of climate change are particularly critical in areas with intensive agricultural activity, making the Lake Egirdir basin one of the most vulnerable regions, especially due to high water withdrawal. The agricultural land around Lake Egirdir covers around 96.000 hectares. In terms of economic yield, fruit production is the most prominent sector, particularly apple cultivation. With the expansion of the area under cultivation areas, the Egirdir Basin now accounts for approximately 25% of Turkiye's total apple production. Other economically important crops include cherry, apricot, and rose. Additionally, dry farming contributes to the local rural economy, and lavender has recently been introduced as an alternative crop.

The land use map (Figure 2) shows that cherry farming dominates the Hoyran sub-basin, particularly in the Uluborlu and Senirkent districts. Apple cultivation is also significant in this sub-basin. The Yalvac-Gelendost sub-basin is primarily focused on apple production, and the remaining sub-basins also feature apple as the dominant crop.

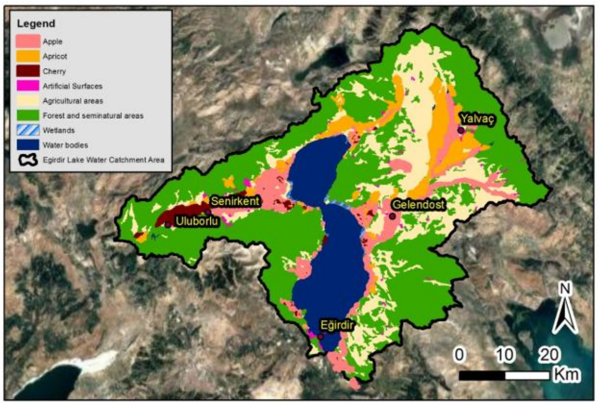

Figure 2. Agricultural production pattern in the Lake Egirdir basin.

Despite the increasing use of pressurized irrigation systems in the basin, their general distribution is still not optimal level. Due to climate change and excessive water withdrawal in recent years, the lake surface shrinkage has led to a shift to well-based irrigation, especially in areas affected by receding shorelines. This practice further contributes to the decline in the lake's water level. According to preliminary data from the General Directorate of State Hydraulic Works (DSI), the amount of water entering the lake due to climate change has decreased annually, dropping to approximately 370 hm^3

annually based on the last five-year average. However, the annual loss of water from the lake's surface is 470 hm³ due to evaporation alone. Combined with other uses, the annual water outflow from the lake during this period has reached approximately 590 hm³. Consequently, the balance between inflow and outflow has been disrupted. Since there isn't much that can be done to address evaporation, it has become mandatory for all irrigation systems to be under the supervision of the DSI. Control of the lake and groundwater is essential to protect this critical water source. It is crucial to reassess irrigation allocations in the Lake Egirdir sub-basins and revise them in line with climate change projections. Key sustainable measures include:

- Identification and licensing of illegal wells
- Installation of meters on all wells and strict monitoring
- Five-year review of water allocations for irrigation based on climate scenarios
- Fair pricing of allocated water

Without these measures, access to water could become increasingly difficult. Irrigation improves both crop productivity and resilience, and limited access to water can exacerbate problems, especially in areas that rely solely on rainfall (Carlisle et al., 2019). In regions such Lake Egirdir with intensive agriculture, the use of organic farming techniques within the 270-meter protection zone outside the "Green Belt Zone" is considered essential. This area is particularly sensitive to diffuse pollution. A previous study calculated the pollutant loads that could reach the lake from all agricultural areas. The calculations found that the nitrogen and phosphorus loads reaching the lake from cultivated agricultural areas were 461.6 and 46.1 tons/year, respectively (Gunes, 2008). Studies show that organic practices significantly reduce nitrate leaching (Mondelaers et al., 2009; Shepherd et al., 2003). If conventional techniques are continued, a degradation of soil functions, a loss of ecosystem services and lower long-term productivity are to be expected (Sharma et al., 2024). Outside the buffer zone, promoting Good Agricultural Practices (GAP) is also critical for the management of lakes and basin management. These two approaches organic agriculture and GAP are the main pillars of sustainable agriculture in the region. In the face of climate change, gradual changes in cropping patterns are needed. This not only helps conserve water but also reduces diffuse pollution from agriculture. For instance, studies show that apple farming requires around 25 pesticide applications per season, while cherry production requires only about 12. Even this difference in pesticide use yields significant environmental and economic benefits. Additionally, promoting dwarf fruit trees in apple orchards contributes positively to this transition.

Regardless of current or planned cropping patterns, urgent implementation of sustainable agricultural practices instead of conventional methods would likely lead to the following outcomes:

i. Efficient water use can alleviate, the critical issue of water scarcity, and in the long term, it may become easier to reach at least the minimum lake water level of 914.62 meters.

ii. Reduce input costs for farmers, thereby increasing profitability and reducing greenhouse gas emissions

iii. With an average lake depth of 3–3.5 m, less pollution can be expected in the drier months (September–November)

iv. Improved productivity of the lake's ecosystem

v. Reduced shoreline recession

vi. Improved livelihoods of communities economically dependent on the lake

vii. Fewer losses in tourism

In addition, the welfare of farmers can be improved through these gains, which strengthens social resilience. These outcomes can only be achieved through effective and continuous awareness-raising, incentives, and regulatory enforcement.

4. Conclusion

The severe water loss observed in Lake Egirdir in recent years has resulted in dual threats: Firstly, increased evaporation due to climate change, and secondly, excessive water consumption in agriculture. If these trends continue, they could lead to a significant restriction or eventual collapse of agricultural activities. Lake Eğirdir, with a maximum water volume of 4000 hm³, has lost approximately 60% of its maximum water volume due to dramatic evaporation due to climate change, coupled with other uses. It is estimated that the lake's water volume will drop to 1500 hm³ after the second half of 2025. Therefore, although it is long overdue, sustainable agricultural policies, the most important investment for the future, must be implemented immediately to ensure the continuity of agriculture in the region.

Author Contributions

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	K.G.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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