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Research Article

Environmental and Climatological Effects of Water Resources-Güneysınır Pond Application

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Keywords

Climatology
Climatological effects,
Irrigation Project,
Environmental effects,
Water resources Project,
Ponds.

Abstract

Ponds and dam lakes constructed for various purposes can alter the local climate by influencing the climate factors of the region. The exchange of heat and mass between large water bodies and air masses leads to microclimatic changes. The environmental and climatological effects of such projects are analyzed through long-term meteorological measurements. Water resource projects play a critical role in areas like agriculture, energy production, and drinking water supply, while also having significant impacts on ecosystems and climate. Specifically, dams and ponds can contribute to environmental issues such as biodiversity loss, disruptions in the hydrological cycle, and greenhouse gas emissions. However, with careful planning and management, these projects can also provide environmental benefits. Developing strategies to maintain ecological balance and adopting sustainable water management policies are essential. Therefore, comprehensive assessments should be conducted during the planning phase of water resource projects, taking into account their long-term environmental and climatological effects. This approach would allow for the most efficient use of water resources without harming natural ecosystems. This study examines the Güneysınır Pond and Irrigation Project, located in the Konya Basin in Turkey and managed by the State Hydraulic Works (DSI). The goal is to assess the ecological, hydrological, and climatological impacts of the Güneysınır Pond and propose measures to ensure environmental sustainability. Among the hydrogeological effects of the pond are the rise in groundwater levels and changes in surface flow regimes. While it contributes to agricultural production by increasing irrigation capacity, uncontrolled water management can lead to problems such as erosion and soil salinity. Therefore, measures should be taken to minimize the environmental impacts of the Güneysınır Pond, and sustainable water management policies should be implemented.

1. Introduction

Water resource projects are vital for the economic development and well-being of societies, playing critical roles in areas such as agriculture, energy production, and drinking water supply. However, the environmental and climatological impacts of these projects must be carefully evaluated during their planning and implementation. Climate change and increasing environmental sensitivities significantly influence the sustainability of water resource projects [1].

Dam constructions, by blocking the natural flow of rivers, can disrupt aquatic habitats and obstruct fish migration routes. For example, China's massive dam project on the Yarlung Tsangpo River in Tibet poses serious threats to local ecosystems and raises water security concerns in downstream countries like India and Bangladesh [2]. Similarly, the Ilısu Dam, constructed as part of Turkey's Southeastern Anatolia Project (GAP), has submerged historically and culturally significant areas like Hasankeyf, leading to significant archaeological losses.

Climate change impacts the water cycle, causing irregularities in rainfall patterns, temperature increases, and higher evaporation rates. This directly affects the quantity and quality of water resources, heightening the risk of water scarcity. In particularly arid and semi-arid regions, the effects of climate change are more pronounced, resulting in issues such as desertification, soil salinization, and erosion. Additionally, reductions in seasonal snow cover and changes in the timing of snowmelt negatively affect the availability and distribution of water resources [3].

The construction and operation of water resource projects can lead to various environmental consequences. For instance, expanding reservoirs may require infrastructure adjustments and lead to changes in ecosystems. The expansion project aimed at increasing the capacity of the San Luis Reservoir in California by 130,000 acre-feet required relocating Highway 152 due to seismic risks. Such projects can disrupt local habitats and incur significant financial costs. Furthermore, water projects can impact water quality and quantity. Updates at the Reed City Wastewater Treatment Plant in Michigan aim to improve water quality by introducing new filtration and disinfection systems. These improvements contribute to sustainable water management by reducing the environmental impacts of wastewater [4].

Climate change significantly impacts water resource projects, altering hydrological cycles and increasing the frequency of extreme weather events. Studies show that climate change is significantly altering rainfall patterns. For example, a study conducted using the SWAT and WEAP models in the Upper Dong Nai River Basin in Vietnam predicts changes in annual river flow due to climate change. This highlights the need to consider climate projections in water resource planning [5].

Similarly, assessments conducted using Regional Climate Models (RCM) in the Mundaú River Basin in Brazil predict significant reductions in annual rainfall and flow under future climate scenarios. These changes could lead to severe issues in water supply for agricultural and domestic use, emphasizing the need for adaptive approaches in water management strategies [6].

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This study addresses the overall environmental impacts of water resources, focusing on their potential effects on the physical-biological environment, flora and fauna, natural geography and geological structure, meteorological and climatological changes, water ecosystems, terrestrial ecosystems, soil resources, air quality, noise and vibration impacts, and infrastructure services. As a case study, Güneysınır pond located in Turkey was evaluated. During the construction of ponds, the disruption of the natural balance inevitably leads to the extinction of certain endemic species. For a sustainable environment, there are essential rules and mandatory practices that must be followed in all agricultural activities. This study discusses the necessary measures to mitigate the negative environmental impacts of water resource projects. The study also examines the effects of the pond on environmental and climatic parameters, particularly temperature, precipitation, and evaporation, and correlates these with climate data. Moreover, the study seeks to demonstrate how regional applications impact climatic changes and the long-term environmental sustainability of water resources management.

2. Materiel

This study focuses on the Güneysınır Pond and Irrigation Project, located in the Konya Closed Basin in Turkey, under the management of the State Hydraulic Works (DSI). The construction of the project began in 2017, and it features a height of 28 meters from the foundation and a water storage capacity of 275,000 m³. Upon completion of the irrigation system, it will irrigate 600 decares of agricultural land through a piped network. As of now, the physical progress of the project is 30%, with the spillway, bottom outlet, and injection works having been completed [7].

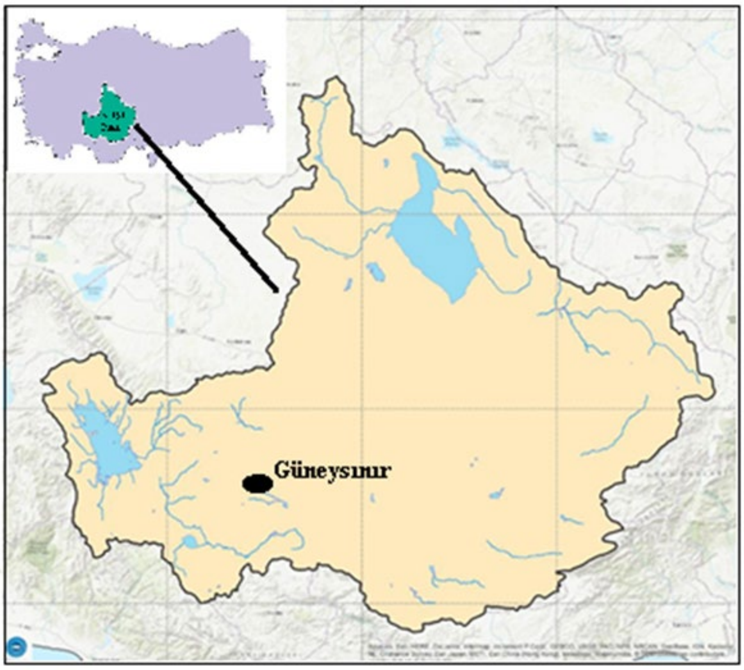

Figure 1. Konya Basin and Güneysınır Pond

The detailed technical specifications of the reservoir constructed with a rock-fill embankment and membrane facing are presented in Table 1.

Table 1. General Features of Konya Güneysınır Pond and Irrigation Project

Group	Classification	Features
Body	Type	Rock-fill with membrane facing
	Purpose	Irrigation
	Stream Bed Elevation	1,250.00 m
	Crest Elevation	1,269.55 m
	Height from Stream Bed	19.55 m
	Height from Foundation	26.82 m
	Crest Width	8.00 m
	Crest Length	157.07 m
	Upstream and downstream slopes	2.00/1 - 2.00/1 horizontal/vertical
	Total Fill Volume of the Body	97,452.60 m³
Reservoir	Active Volume	0.250 hm³
	Dead Volume	0.0255 hm³
	Normal Storage Volume	0.2755 hm³
	Minimum Water Level	1,258.35 m
	Normal Water Level	1,267.85 m
	Maximum Water Level	1,268.45 m
Irrigation System	Gross Irrigated Area	60 ha
	Net Irrigated Area	54 ha
	Irrigation Water Requirement	4,198.95 m³/ha/year
	Irrigation Module	0.60 l/s/ha
	Active Water Requirement	200,000 m³

Field data were collected from data collected by DSI, Turkish Ministry of Agriculture and Forestry during project design, temperature, precipitation data from the General Directorate of State Meteorology. Data were evaluated for different time periods in a year. In order to analyze climatic variations in the region, data from Automatic Meteorological Observation Station No. 18495, operated by the General Directorate of Meteorology (DMG) and located 12 km from the project site, were employed.

Regarding the general environmental impacts of water resources; possible effects on the physical-biological environment, effects on flora-fauna, effects on natural geography and geological structure, meteorological and climatic changes, effects on the aquatic ecosystem, effects on the terrestrial ecosystem, effects on soil resources, effects on air quality, noise and vibration effects and effects on infrastructure services can be mentioned.

3. Methodology

In this study, a methodological approach based on quantitative data was adopted to evaluate the water management performance of Güneysınır Pond. The study was carried out by integrating field observations, secondary data analyses and various analytical tools.

Meteorological data and photo-supported observation forms were used in the field research. Observations were conducted monthly over a six-month period, with sampling times determined based on seasonal variations. The Mann-Kendall test was applied to analyze changes in climate parameters (temperature, precipitation, evaporation). For this process, data created in Microsoft Excel were utilized..

The Mann-Kendall (MK) test is a non-parametric statistical method used to assess whether there is a monotonic trend in a dataset over time. It is widely used for trend analysis in environmental and climate data, such as temperature, precipitation, and other parameters. In the Mann-Kendall test, the observations $x_1,\ldots,x_n$ ordered by time are random variables with similar distributions and independent of time according to the H_o hypothesis.. According to the H_1 hypothesis, the distribution of x_k and x_j values in the series is not similar for all $(k,j \leq n)$ including $(k \neq j)$ that is, there is a linear trend in the series. The statistics (S) of this test, which is applied to the data with the seasonality removed as in Sen's T test, is calculated from the equations (1) and (2).

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}\left(x_j - x_k\right) \tag{1}$$

$$\operatorname{sgn}\left(x_j - x_k\right) = \begin{Bmatrix} +1 & \text{if} & \left(x_j - x_k\right) > 0 \\ 0 & \text{if} & \left(x_j - x_k\right) = 0 \\ -1 & \text{if} & \left(x_j - x_k\right) < 0 \end{Bmatrix} \tag{2}$$

The variance of the test statistic S, which has an asymptotically normal distribution and a mean of zero, is calculated as $Var(S)=n(n-1)(2n+5)/18$. If there are similar values (tie status) in the data, the value $\sum_t t(t-1)(2t+5)$) is subtracted from the numerator of this expression. Here t represents the number of similar x's in any tie status and $\sum_t$ represents the sum over all tie statuses. If the continuity correction unit is used, the normal distribution is quite suitable for the theoretical probability distribution of the S statistic, where $n \leq 10$. As a result, the standard normal variable (z) is calculated with the following equation and compared with the critical z value.

$$z = \begin{Bmatrix} \dfrac{S-1}{\sqrt{Var(S)}} & eğer & S > 0 \\ 0 & eğer & S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & eğer & S < 0 \end{Bmatrix} \tag{3}$$

If α is at the significance level $|z| \leq z_{\alpha/2}$ then the H_o hypothesis is accepted, otherwise it is rejected. If the calculated S value is positive, it indicates the existence of an increasing trend, if negative, it indicates the existence of a decreasing trend. This technique is useful because it does not take into account the existence of missing data and does not require the data to conform to a certain distribution.

The fieldwork was specifically focused on assessing the vegetation status. Photographs documenting the fieldwork are presented in Figure 2, while landscape images taken before and after the construction of the reservoir are shown in Figure 3.

Figure 2. Photographs showing vegetation status

(a) (b)

Figure 3. before (a)-and-after (b) landscape photos of Güneysınır Plot

This methodological framework made it possible to make a comprehensive assessment of the current status of Güneysınır Pond in both spatial and temporal contexts. Evaluation Methods and Criteria for the impacts of the pond are explained in a separate section.

4. Evaluation Methods and Criteria

Ponds are structures built for the purpose of water storage and management, and they have various ecological, geomorphological, and climatological impacts on their surrounding environment. In this article, the effects of ponds on flora and fauna, aquatic species, geomorphological structures, landscape integrity, meteorological and hydrogeological conditions, hydraulic and ecological structures, environmental benefits, groundwater and surface water resources, agricultural and pasture areas, and climatological impacts will be addressed.

4.1. Effects of the pond on flora and fauna, evaluation, and measures to be taken

The construction of ponds directly impacts the habitats of plant (flora) and animal (fauna) species in the area. Land plants disappear in submerged areas, while new habitats are created for aquatic plants. This change may lead to an increase in the populations of some species, while others may decrease or disappear. For example, in biological pond designs, using species native to the region's natural vegetation helps enrich the ecosystem and balance conservation and use. Therefore, in pond projects, a detailed inventory study of the existing flora and fauna should be conducted, and necessary measures should be taken to protect species [8].

4.2. Evaluation of the pond in terms of aquatic species

Ponds create new habitats for aquatic ecosystems. However, these new habitats may affect the distribution and population dynamics of existing aquatic species. For example, in the design of artificial wetlands, the use of various aquatic plants and shore plants can increase the diversity of aquatic ecosystems. Since the water quality of ponds, temperature regimes, and nutrient cycles directly affect aquatic organisms, it is important to monitor and manage these factors regularly [9].

4.3. Potential effects of the pond on geomorphological structures such as canyons, springs, caves, and valleys

Pond construction may cause significant changes in the surrounding geomorphological structures. For example, creating a pond may alter the flow regime of water, affecting erosion and sedimentation processes in natural formations like canyons, springs, caves, and valleys. Studies conducted in the Dinar Çağlayan Creek Basin reveal the effects of ponds on geomorphological structures and how these effects should be managed. Therefore, when planning pond projects, the geomorphological characteristics of the area should be thoroughly examined, and any potential negative effects should be minimized [10].

4.4. Impact of the pond on landscape integrity

Ponds can alter the physical structure of the landscape, affecting the visual and ecological integrity of the area. A study conducted on Sultanbeyli Pond Park shows how landscape integrity can be preserved with water and energy-efficient solutions in line with sustainable landscape design criteria. In this context, the environmental design of ponds should be planned to harmonize with natural landscape elements and be arranged to support ecosystem services.

4.5. Meteorological and hydrogeological effects of the pond

Ponds may affect microclimatic conditions and groundwater levels. Surface water bodies can alter local temperature and precipitation regimes by changing the atmospheric humidity balance through evaporation. Additionally, ponds can increase or decrease groundwater recharge. Studies in Atikhisar Dam Lake examine the relationship between meteorological drought and hydrological drought, and their impacts on water resources. Therefore, the hydrogeological effects of pond projects should be analyzed in detail to ensure the sustainability of water resources [11].

4.6. Effects of the pond on hydraulic and ecological structure

The construction of ponds alters the flow regime of water, which affects hydraulic balance and ecological structure. The slowing down of water flow can lead to sediment accumulation and a decrease in water quality. In biological pond designs, using natural vegetation contributes to enriching the ecosystem and improving water quality. Therefore, measures should be taken in pond designs to maintain hydraulic and ecological balance [8].

4.7. Environmental benefits of the project

When properly planned and managed, pond projects can provide various environmental benefits such as water storage, flood control, recreation areas, and increased biodiversity. For example, the Kastamonu-Araç Tuzaklı Pond performs important ecological functions, such as providing a habitat for aquatic life, controlling erosion, flood protection, creating microclimates, and preventing water pollution. Such projects contribute to environmental sustainability by supporting ecosystem services in the region [12].

4.8. Effects of the pond on groundwater and surface water resources

Ponds can have both positive and negative effects on groundwater and surface water resources. When properly designed, they can help preserve and recharge groundwater levels. However, excessive water extraction and poor management can lead to a decline in groundwater reserves and issues such as salinization. Therefore, the impacts of ponds on water resources should be carefully evaluated, and sustainable water management strategies should be developed [13].

4.9. Effects of the pond on agricultural areas

Ponds can enhance agricultural productivity by providing water for irrigation. Many dams and ponds built in Turkey allow for the irrigation of vast agricultural lands. The increase in irrigation opportunities contributes to the variety and yield of crops. However, the effective use of water and proper management of irrigation systems are crucial for the sustainability of water resources.

4.10. Potential effects of the pond on pasture areas

Pond construction can increase the grazing capacity of pasture areas by meeting their water needs. However, improper planning and management can lead to pastures being submerged or degraded. A study conducted in the Tokat Artova region found that the dry hay yield and grazing capacity of pasture areas decreased, which resulted in an increase in the pasture area per animal. Therefore, the effects of pond projects on pasture areas should be carefully evaluated [14].

4.11. Climatic effects of the pond

The climatic effects of a pond can be significant, particularly in areas where water bodies are artificially created. Large ponds alter the local microclimate by influencing temperature, humidity, and precipitation patterns. The presence of a water body can moderate temperature extremes, making the surrounding area cooler in the summer and warmer in the winter. This effect is often referred to as the "lake effect," where the large mass of water absorbs heat during the day and releases it slowly at night. Additionally, increased evaporation from the water surface can raise local humidity levels, potentially leading to more cloud formation and increased precipitation in the area.

Ponds can also affect wind patterns and air circulation due to the differences in heat absorption and release between the water and surrounding land. This change in airflow can impact regional climate, potentially leading to shifts in local weather conditions. In some cases, the presence of a large water body can create conditions that encourage the formation of storms or alter natural wind patterns, influencing both local ecosystems and human activities. Over time, the climatic modifications resulting from the pond can have far-reaching effects on agriculture, water resources, and even the health of the local environment [15].

5. Environmental and Hydroclimatological Evaluation of the Güneysınır Pond Project

5.1. Effects of the pond on flora and fauna, evaluation

Turkey is located in one of the world's richest geographical regions in terms of plant diversity. The world is divided into 37 different regions based on plant diversity, known as phytogeographic or flora regions, and three of these regions intersect over Anatolia. These are:

➢ Iran-Turan Phytogeographic Region

➢ Europe-Siberia Phytogeographic Region

➢ Mediterranean Phytogeographic Region

The Iran-Turan phytogeographic region covers Central Anatolia, Eastern, and Southeastern Anatolia. The Europe-Siberia phytogeographic region covers the Black Sea region, while the Mediterranean phytogeographic region encompasses the Aegean, Marmara, and the southern part of the Taurus Mountains. The pond area is located in the Central Anatolian Section area shown in Figure 4. Field studies have shown that the flora area is compatible with the region.

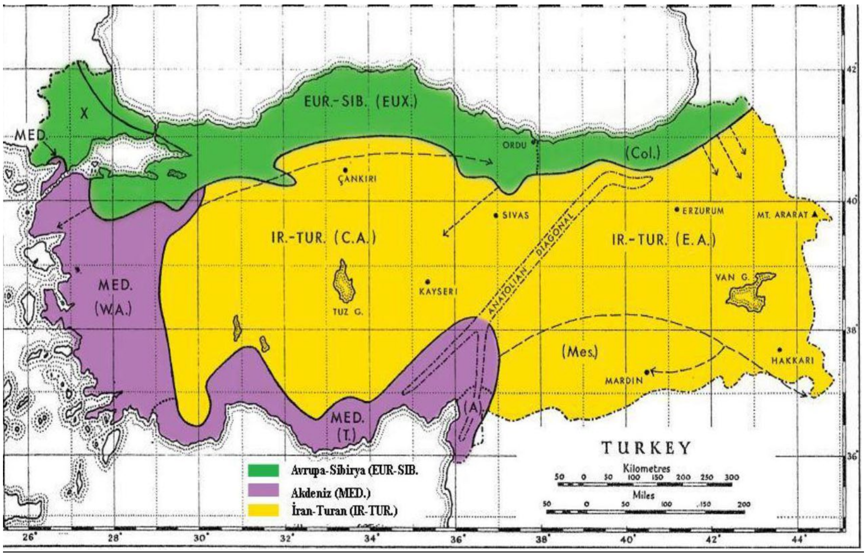

Figure 4. Flora Regions of Turkey

- IR-TUR: Iran-Turan Flora Region
- C.A.: Central Anatolian Section
- E.A.: Eastern Anatolian Section
- Mes.: Mesopotamia
- MED: Mediterranean Flora Region
- W.A: Western Mediterranean Section - Eastern Mediterranean Section
- T.: Taurus Region
- A.: Amanos Region
- EUR-SIB.: Euro-Siberian Flora Region
- EUX: Euxine Section
- Col.: Colchic Sector of the Euxine Section
- X: Probably the Central Europe/Balkans Subregion of the Euro-Siberian Region

Turkey, with its rich flora, hosts species that exhibit both wide distributions and those that can only be found in specific regions. Species with broad distributions, which can be observed in every region, are referred to as "cosmopolitan" species, while those with narrow distributions, found only in certain areas, are called "endemic" species. The range of endemic species can vary significantly. Endemic species found in a limited area are referred to as "local endemics," whereas those with a broader distribution are classified as "wide-ranging endemic species."

The identification of the fauna within the project area and its influence zone is based on field observations, detailed literature research, and a survey conducted with the local community regarding wildlife. In the survey, questions were asked about whether hunting is carried out in the area, which animals are hunted if so, the local names of animals seen in the region, etc. To identify fauna elements (amphibians, reptiles, birds, and mammals), fieldwork was conducted in the project area and its surroundings, focusing on areas near water sources, under rocks and stones, rock crevices, tree hollows, etc. No traps were set to avoid harming the fauna elements. During fieldwork, feathers, pellets, tracks, bird sounds, and visual inspections were conducted. The following materials were used during these activities: Nikon P100 camera, Canon 70D camera, Canon 300mm lens, Nikon 8X40 binoculars, a 1/25,000 scale topographic map of the region, and a notebook.

According to result of the literature review, 1 amphibian species was identified in the project area and impact area. The nightingale frog species, which is from the BUFONIDAE family and is in the low-risk group, has been found to live in gardens, open stony areas, and near water. It has been determined that this species continued to exist during the project as it did before the project.

As a result of the literature review, 1 amphibian species was identified in the project area and impact area. Also, 7 reptile species are likely to be found in the project area and its influence zone. According to the Bern Convention: 4 species are listed in Annex II of the Bern Convention, and 3 species are listed in Annex III. According to the IUCN Red List: Based on IUCN criteria, 1 species is classified as "VU - Vulnerable" and 4 species are categorized as "LC - Least Concern.". According to the literature review, 10 bird species are likely to be found in the project area and its influence zone.

Some of the most important bird migration routes of the Western Palearctic region pass through Turkey. In addition, there are numerous local migration routes of lesser importance within Turkey. Although these routes generally pass through broad river valleys, they can often deviate from their paths. One of the major migration routes crossing Turkey passes through the Bosporus, while another enters the country through the Eastern Black Sea. In addition to these two main migration routes, there are also less significant secondary migration routes. These routes are used by bird populations with fewer species and relatively lower individual numbers. Another migration behavior exhibited by passerine species is the migration across all suitable areas.
Especially in autumn, this migration behavior occurs over much larger areas. These movements, which may occur in very small groups or as individual transitions, can be observed throughout Turkey.
When considering the migration movements in a geographical location like Turkey, which is considered a "Migration Country" for bird species, and evaluating their interaction with the project area, there is no main or secondary bird migration route passing through the project area among the major or minor migration routes mentioned above. The project area is not a location that is significantly used during irregular and small-scale migratory movements that take place during the spring and autumn migration periods.

Due to factors such as noise, mobility, and dust caused by activities in the area, temporary or permanent transformations will occur in natural environments and wildlife that rely on those environments. As a result, individuals that naturally move away from these factors will search for suitable, similar habitats in the nearby surroundings. In this case, issues such as the carrying capacity of the new areas for wildlife and competition with other species may arise. However, observations and studies conducted in the project area and its immediate surroundings have shown that the species do not have very dense populations. Additionally, alternative new habitats are available for these species in the project area and surrounding areas. Therefore, it is not expected that wild forms moving away from their original habitats will face problems in finding new habitats in these areas.

Wildlife species that do not naturally move away during the studies will be captured using appropriate capture equipment and methods, and will be relocated to similar habitats in the nearby area. Furthermore, with certain precautions, it will be possible to prevent individual losses. There are no specific endemic or protected species in the project area. Although there are invasive species, monitoring or containment strategies have been determined.

5.1.1. Impact of dust emissions on flora and fauna and mitigation measures

Dust emissions, especially when they form a layer on plant leaves, can cause the stomata to close, hindering the exchange of gases. Over time, this can lead to the wilting and drying of plant leaves, preventing fertilization. The preparation of the areas where the body and facilities will be located, as well as the unloading of materials for construction, may result in high levels of dust emissions. However, by taking the necessary precautions, the local vegetation and wildlife habitats used by wild species can be protected from adverse effects of dust.
To minimize or eliminate the effects of dust emissions from the project, the following measures will be implemented:

- Care and attention will be given when opening new roads or expanding and improving existing ones to prevent harm to wildlife species residing in or passing through these areas.
- Wildlife will be allowed to naturally move away from the project area before, during, or after any construction activities, thus avoiding harm from disturbances.
- In cases where wildlife cannot move away due to stress or shock, they will be captured by trained personnel using appropriate methods and relocated to suitable habitats.
- In areas that require transformation, special care will be taken to preserve undisturbed natural areas, which will help maintain the local wildlife and habitat integrity.
- Dust emissions will be minimized by employing measures such as consistent watering of construction areas, covering vehicle beds during transport, and adhering to speed limits. By following these measures, dust emissions will be reduced significantly, preventing negative impacts on local vegetation and wildlife.

5.1.2. Impact of construction noise on flora and fauna and mitigation measures

Construction activities will generate noise from various sources at different levels and times. Wildlife is often more sensitive to lower decibel levels compared to humans. This noise may cause species to abandon their habitats or suspend essential activities such as feeding, resting, and breeding.

When construction starts in the project area, species engaged in breeding could be disrupted, and if the noise from vehicles is too loud, it may result in abandoned nests or interrupted rearing activities. Measures will be implemented to ensure the noise does not compel wildlife to leave the area.

Given the short duration of construction for reservoir projects, adjustments to the schedule can minimize noise-related impacts, especially during breeding seasons.

It is essential that loud noise is avoided after breeding activities have commenced. If noise occurs early in the breeding season, species may relocate to nearby habitats with similar features, allowing them to continue their activities without significant impact.

Additional Mitigation Measures:

- To prevent soil piles from sliding in the plant soil storage area, stability will be ensured. Drainage channels will be constructed around the storage area to collect rainwater, preventing erosion. The stored plant soil will be watered during dry periods to maintain moisture. To support the natural cycle, the soil will be periodically mixed, ensuring that conditions remain suitable for plant growth.

- After construction, the stored plant soil will be used for landscape restoration. The seeds within the soil will germinate when re-applied, helping the area return to its natural state faster.

- Temporary roads will be kept narrow and short to minimize environmental impact.

- Construction workers will be educated to prevent illegal hunting in the area.

- Straying from the designated routes will be avoided to reduce disturbance to the environment.

- Excavation waste will be stored in designated areas to avoid contamination of riverbeds or forests.

- National (MAK) and international (BERN, CITES) environmental agreements will be followed during construction.

- Environmental flow (water release) from the reservoir will be provided downstream to support the flora and fauna that rely on the water in the riverbed.

- Restoration will focus on using native species, ensuring high survival rates and supporting local wildlife habitats after construction is completed.

5.2. Evaluation of the reservoir for aquatic species

Rivers, based on ecosystem types, are categorized under freshwater ecosystems and specifically fall within river ecosystems. The location of the planned Güneysınır Reservoir is situated on the Kafabağ stream. The Kafabağ stream does not have continuous flow, as it is dry during certain periods. As a result, the reservoir that will be constructed in the stream bed, which has a flow characteristic influenced by seasonal rainfall, will create favorable environmental conditions for planktonic organisms due to the physical factors of the terrestrial ecosystem. Therefore, it is expected that the reservoir project will not negatively impact aquatic life, particularly algae (especially phytoplanktonic organisms) and zooplanktonic organisms.

Throughout both the construction and operational phases of the planned project, environmental water flow released from the reservoir will ensure the continuity of life for the species that are part of the regional ecosystem. This will help preserve the local vegetation, fauna, habitats, and biotopes in the area.

5.3. Potential Impact of the reservoir on geomorphological structures such as canyons, pits, caves, valleys, etc.

There are no geomorphological structures such as canyons, pits, caves, or valleys in the project area or its surroundings.

5.4. Impact of the reservoir on landscape integrity

It is anticipated that some of the excavation waste generated from excavation activities will be plant soil. This stripped plant soil will later be used for landscape restoration activities in the project area and for the landscaping of recreational areas. Excavation materials other than plant soil will be used as backfill for walls, pipe trench backfill in the irrigation network, and as filling material for the new service road.

The activities of the project will cause temporary effects on the natural structure of the area and on wildlife species benefiting from the natural environment. During the construction phase, natural vegetation will be disturbed, and the ecosystem balance will temporarily be disrupted due to interventions. Once the project is completed and the reservoir is operational, the area will be rehabilitated through afforestation, erosion control projects, and landscape works, considering the area's topographical (general and specific location), edaphic (substrate, soil), climatic (precipitation, temperature), and biotic (vegetation, biological constraints) features.

5.5. Meteorological and hydrogeological impact of the reservoir

It is not anticipated that the operational activities within the scope of the project will have a significant impact on local meteorological conditions. The total evaporation amount was determined using the Reference Annual Total Evaporation (ETo) Normal Map, published by the General Directorate of Meteorology [16], as shown in Figure 5. Accordingly, the average annual evaporation in the area where the Güneysınır Pond is located is between 950.1 and 950 mm/year. Assuming the maximum possible evaporation amount (950 mm/year), the annual net evaporation value has been estimated at 717.1 mm. Due to the characteristics of the terrain, the limited groundwater flow in the study area is directed from the slopes towards the river. The implementation of the project is not expected to result in any significant changes in the current hydrogeological conditions.

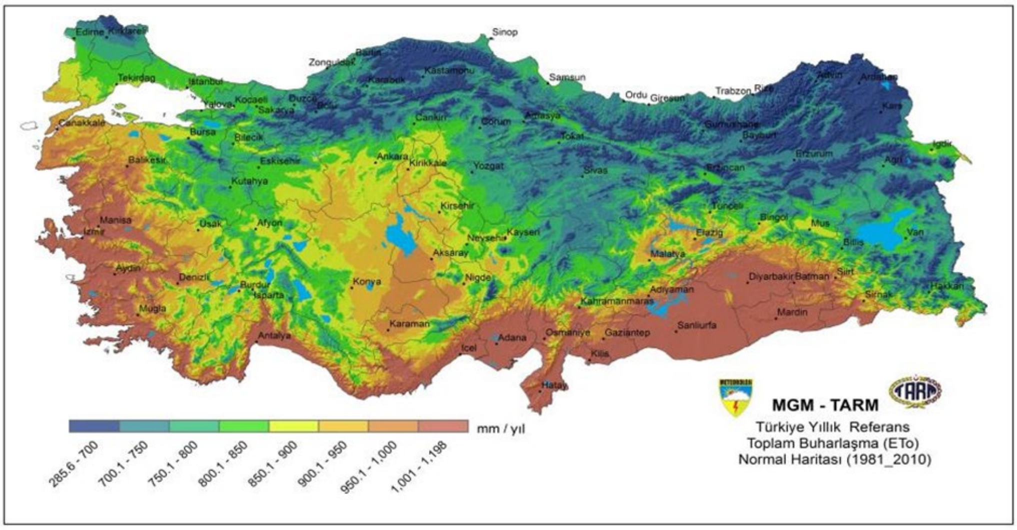

Figure 5. The annual reference total evaporation normal map

5.6. Hydraulic and ecological impact of the reservoir

The annual total flow calculated from the Kafabağ Stream, where the Güneysınır reservoir will be located, is 0.055 hm^3. It is planned to store winter rainfall and use the water for irrigation during the irrigation season. The relationship between surface and groundwater and the potential impacts of the project are not expected to cause changes that would affect the current surface-groundwater interaction.

Aquatic species are not typically found in the stream bed during dry and drought periods. However, after the reservoir is constructed, a certain amount of water will be released into the stream bed during periods of flow, ensuring the continuity of the ecological structure in the downstream section.

5.7. Environmental, social and economic benefits of the project

Once completed, the reservoir area will be transformed into a recreational area with picnic spots, promoting greenery in the surrounding environment. Additionally, the local community will have access to recreational and walking areas. With the development of these recreational areas, visitor frequency will increase, boosting nature tourism. Afforestation around the reservoir will create a beautiful landscape and recreational space while also combating erosion. The forests will raise the relative humidity in the area and cause a transition from a continental to a milder climate. As a result of the project, agricultural product quality and yield are expected to increase, enhancing the economic power of the local population and positively affecting their social lives and cultural levels. Research has shown that economic development positively impacts society's environmental perspective. Thus, the economic progress brought by the project will indirectly benefit the environment. Additionally, the increase in green areas due to irrigation is expected to have a mild positive impact on air quality in the long term.

If we evaluate it in terms of social science dimensions, although the local people may be victimized as a result of expropriation, with the completion of the Güneysınır Reservoir and Irrigation Supplementary Construction, 600 decares of agricultural land will be irrigated with the water to be stored in the reservoir.

In addition, the Güneysınır Reservoir is used in the irrigation of agricultural lands with drip irrigation and in vegetable and fruit cultivation. In addition, amateur fishermen spend time fishing with rods in the ponds, and the residents of the area have picnics around the ponds, especially on weekends. With the sufficient water storage of the ponds in Güneysınır, extremely positive developments have begun to occur in terms of ecology within the district borders. Previously unseen bird species have also begun to be seen in the vicinity of the pond, which has a very clean air and environment by nature. The ponds, which are expected to become a bird paradise by the local residents after a while, have started to attract the attention of nature lovers, photographers and bird watchers.

This will also have a positive contribution to the local people in social and economic terms.

5.8. Impact of the reservoir on underground and surface water resources

From a hydrogeological perspective, the water level in the reservoir will rise, causing an increase in the groundwater level on the upstream side of the reservoir. On the downstream side, however, the groundwater level will gradually be lower compared to the upstream side.

When water is stored in the reservoir, chemical and physical changes in water quality will occur. The most significant physical change will be the variation in water temperature. In the reservoir, surface water will be warmer than the deeper water during summer months, leading to thermal stratification. This thermal stratification is one of the reasons behind changes in water quality.

The most significant chemical change in the water will be in the dissolved oxygen concentration. The primary factor that may increase the dissolved oxygen in the reservoir is the organic matter in the stream water. Before water is stored in the reservoir, vegetation in the submerged areas will be cleared, so water quality is not expected to degrade significantly. However, some oxygen depletion may occur during the first few years. As suspended solids (SS) settle in the reservoir, water turbidity will decrease, improving water quality. This will allow more sunlight to penetrate the water, increasing photosynthesis and, in turn, biological productivity.

5.9. Impact of the reservoir on agricultural areas

5.9.1. Salinization

The primary objective of irrigation is to create a favorable balance between water, soil, and plants. Thus, irrigation is defined as a process that provides adequate moisture conditions for plant growth. If the soil contains excessive moisture, irrigation can result in a decrease in crop yield and, more importantly, issues like soil salinity, alkalinity, and groundwater problems. Groundwater, defined as water that remains saturated below an impermeable layer, is harmful to plants.

Even the best-quality irrigation water brings salts, which accumulate in the plant root zone as the water evaporates. Excessive rainfall and irrigation can wash the salts deeper into the soil profile, causing them to enter groundwater. The salts accumulated in the root zone affect plants and soil based on their characteristics and concentration.

Salinity in irrigated areas is a major cause of land degradation and environmental impact. Saline conditions limit plant selection, affecting germination and crop yield. Measures such as leaching, changing the irrigation method, installing sub-surface drainage, altering plant composition, and soil improvement can reduce salinity and minimize its negative impact on plants. No adverse effects on the soil structure are expected with the planned irrigation in this project. Excess water will be removed from the plant root zone through drainage channels, allowing the soil to aerate, and plant roots will grow deeper, benefiting from better nutrition and fostering beneficial bacterial activity in the soil. Additionally, salt accumulation will be prevented, and soil will become easier to cultivate.

5.9.2. Boron effect

Plants are highly sensitive to boron toxicity, and even small changes in boron levels in the soil or water can lead to toxicity. Contamination of irrigation water or agricultural land with toxic elements is one of the major factors limiting agricultural production. If boron concentration in irrigation water exceeds certain thresholds, plant growth will halt. Yellowing, burning, and browning of plant leaves, as well as slowed growth and decreased yield, are typical signs of boron toxicity. Irrigation with water containing more than 1 ppm of boron can create problems for plants and soil [17].

5.10. Impact of the reservoir on pasture areas

If pasture land is involved in the project, a request for a change of land use purpose will be submitted to the Provincial Pasture Commission according to Article 14 of the Pasture Law No. 4342. The provisions of the Pasture Law No. 4342 will be adhered to for pasture lands.

5.11. Climatological effects of the reservoir

5.11.1. Expected climatic changes

- **Temperature**

The annual temperature statistics for the period 2014–2019 were calculated as follows:

Mean temperature: 12°C

Maximum temperature: 38°C

Minimum temperature: -18°C

Standard deviation: 9.33

Skewness: -0.72

Kurtosis: -1.48

The total precipitation statistics for the period 2019–2024 were calculated as follows:

Mean temperature: 11°C

Maximum temperature: 40°C

Minimum temperature: -15°C

Standard deviation: 9.17

Skewness: -0.78

Kurtosis: -1.51

Reservoirs have a low albedo, meaning they absorb most of the solar radiation. Water heats up and cools down slower than land, which leads to cooling of the air in spring and summer and warming of the air in fall and winter. Various studies have shown that in prjos with similar size and geographical features, there will be a change of 0.5-1 ^{0}C in air temperatures before and after the pond [18]. . The temperature regulation by water bodies reduces convective movements and, therefore, convective rainfall around the reservoir during spring and summer, but increases these movements in the fall and winter.

Additionally, to determine the variation in temperature, a trend analysis was conducted for both the pre-project and post-project periods using temperature data obtained from the observation station. However, since the station has been operational only since 2014, data from the Çumra station (No. 17900), located within the same sub-basin and closest to the reservoir, were used for the trend analysis. This station has been in operation from 1972 to 2024.

The Mann-Kendall test was performed for trend analysis. The test statistics indicated a p-value of 0, a Z-value of 5.29, and a statistically significant increasing trend at the 95% confidence level.

- **Wind**

Due to the smooth surface of the reservoir, wind friction is reduced, and wind speeds may increase by 15-20% compared to before the reservoir, directly proportional to the reservoir's fetch size [198].

- **Freezing – Frost**

In winter, the reservoir acts as a heat source, slowly releasing heat into the atmosphere, reducing the likelihood of frost and freezing compared to before the reservoir. However, on windy days, frost may increase due to the higher wind speeds.

- **Evaporation – Humidity**

Evaporation is directly proportional to the surface area of the water and inversely proportional to depth. With the construction of the reservoir, there will be an increase in evaporation, humidity, and fog events. As part of the analysis of potential evapotranspiration trends, evapotranspiration data calculated using the Thornthwaite method, which is commonly used in drought analysis, were utilized. The Mann-Kendall trend analysis was conducted for potential evapotranspiration data, yielding a p-value of 0, a Z-value of 5.02, and an increasing trend.

- **Precipitation**

The annual total precipitation statistics for the period 2014–2019 were calculated as follows:

Mean total precipitation: 503.75 mm

Maximum total precipitation: 553.40 mm

Minimum total precipitation: 408.70 mm

Standard deviation: 60.71

Skewness: -0.98

Kurtosis: -1.65

The total precipitation statistics for the period 2019–2024 were calculated as follows:

Mean total precipitation: 497.75 mm

Maximum total precipitation: 553.40 mm

Minimum total precipitation: 399.20 mm

Standard deviation: 58.21

Skewness: -0.96

Kurtosis: -1.63

An evaluation of the precipitation statistics before and after the reservoir construction indicates no significant difference in precipitation levels..Research conducted in various countries shows that reservoirs regulate rainfall regimes, causing shifts during rainy months. They decrease convective rainfall in summer To assess the variations in precipitation, a trend analysis was conducted on the monthly total precipitation data for both the pre-project and post-project periods. However, due to the fact that the observation station has been operational only since 2014, performing a trend analysis using its data would not yield reliable results.

Therefore, for the trend analysis, data from the Çumra station (ID 17900), which is located within the same sub-basin and at the closest distance to the reservoir, were utilized. This station has been operational from 1972 to 2024. The Mann-Kendall test was applied to these data, and the resulting test statistics indicated a p-value of 0.96 and a Z-value of 0.04, suggesting an increasing trend in precipitation.and increase it in winter.

5.11.2. Effects of climatic changes on flora and fauna

The area where the project will be implemented is relatively small. Following the construction of the reservoir, the increase in the water surface will lead to an increase in evaporation. The area and its surroundings have relatively sparse vegetation, and it is known that vegetation plays the most significant role in determining the ambient humidity. With the increase in humidity, plants that prefer moisture and can remain green for longer will spread in the project area. This increase in humidity will likely cause animals that cannot tolerate fluctuations in moisture levels to leave the area. However, most terrestrial vertebrates can adapt to various moisture conditions, so the changes in humidity will not negatively affect the vertebrate fauna in the area.

As a result, the creation of the reservoir will lead to an increase in local humidity, creating a microclimate. Since the reservoir area is small and considering the availability of existing water sources in the region, the expected impact on climate change, habitats, and biotopes will not be significant.

6. Conclusions

Water resource projects play a critical role in social development. However, during the planning and implementation of these projects, environmental and climatological impacts must be taken into consideration. Through comprehensive assessments and adaptive management practices, the benefits of these projects can be balanced within the framework of natural resource conservation and climate change mitigation.

Considering the effects of climate change and environmental factors on water resources, adopting integrated and ecosystem-based approaches is essential for the preservation and sustainable transfer of these resources to future generations.

This study comprehensively examines the potential environmental, hydrological, geomorphological, and ecological impacts associated with the construction of the Güneysınır Pond. The analyses indicate that the pond may cause significant alterations to the natural balance of the region. However, with appropriate planning and conservation measures, these impacts can be minimized.

The construction of the pond is expected to lead to notable changes in the region's vegetation and fauna. In particular, the water retention process may alter the habitats of some endemic and water-sensitive species. Additionally, the development of aquatic ecosystems could facilitate the adaptation of new species to the region. In this process, monitoring and, if necessary, rehabilitating habitats around the pond is of great importance for preserving biodiversity.

As the pond fills, it is anticipated that certain aquatic species native to the region will develop. However, the proliferation of invasive species unfamiliar to the ecosystem is also a possibility. This situation could have adverse effects on biodiversity. Therefore, the introduction of aquatic species into the pond should be determined based on scientific principles and kept under strict control.

From a geomorphological perspective, the pond is expected to have direct or indirect effects on natural formations such as canyons, sinkholes, caves, and valleys. Changes in water levels may trigger erosion processes and cause collapses or blockages in some underground formations. Consequently, geological surveys must be conducted meticulously during the construction phase, and necessary measures should be taken to protect the surrounding natural structures.

The new water body formed by the pond will alter the landscape integrity of the region and lead to the emergence of a water-centered ecological structure. This transformation must be evaluated in conjunction with agricultural fields, pastures, and forested areas to ensure the reservoir is harmoniously integrated with the natural environment. Landscape planning should incorporate designs that maintain the ecological balance and prioritize sustainable environmental management.

Microclimatic changes induced by the pond could significantly affect local temperature, humidity, and precipitation patterns. The evaporation process from the water body may increase atmospheric humidity, leading to variations in diurnal temperature fluctuations in certain areas. From a hydrogeological perspective, the pond could cause changes in groundwater levels. As the pond may influence the hydrological regime of nearby water sources, careful monitoring of the filling and discharge processes is required.

The pond will reshape the region's hydraulic balance in terms of water management. While it is expected to provide an essential water source for agricultural irrigation, livestock farming, and potable water, it will also impact the region's ecological structure. To prevent disruptions in the natural flow regime and ensure the sustainable use of water resources, long-term water management policies must be developed. If properly managed, the Güneysınır Pond can provide various environmental benefits. It may enhance agricultural productivity, contribute to erosion control, and promote the expansion of green spaces in certain areas. Additionally, utilizing the pond surroundings for recreational purposes could support ecotourism and create economic opportunities for local communities.

The pond's water retention structure will impact both surface and groundwater resources. Changes in groundwater levels may alter the discharge rates of nearby wells. To prevent issues such as excessive water extraction, an integrated water management approach should be adopted. The construction of the pond is expected to increase agricultural production capacity. Particularly in regions where low water availability limits yield, the pond's water supply is projected to enhance crop diversity and productivity. However, effective water use planning and the promotion of sustainable agricultural practices are essential.

Compared to the Vietnam case, the hydrological and water management dynamics of the studied region are different. In order for these models to work effectively, they must be suitable for certain geographical and climatic conditions. If the region does not have optimal data and modeling conditions for SWAT or WEAP, these models may not be suitable for use. Direct measurements used in the study may provide better answers to the research questions, as can statistical analyses or more local-scale modeling techniques.

Pasture areas surrounding the pond will benefit from improved water availability. However, some pasturelands may be submerged or rendered unusable due to the pond's construction. Therefore, it is crucial to compensate livestock farmers for potential land losses and establish alternative grazing areas. The water body formed by the pond could lead to specific regional climate changes. Increased humidity and temperature variations may influence the local microclimate. The long-term effects of these changes should be monitored throughout the operational phase of the pond, and adaptation strategies should be developed accordingly.

Within the scope of this study, the engineering, hydrological, and environmental impacts of the ongoing construction of the Güneysınır Pond were examined in detail, and the potential advantages and risks were evaluated in line with current planning efforts. The analyses demonstrate that while the pond represents a significant investment in regional water resource management, several critical aspects must be carefully considered for a successful and sustainable operational process. First and foremost, the primary objective of the pond—meeting agricultural irrigation needs—must be optimized based on the existing water budget and climatic variability. Failure to manage water resources efficiently may result in future water shortages and distribution imbalances.

Since the study aims to reach concrete conclusions with data obtained directly from the field, theoretical discussions are given less space. However, this does not mean that these issues are ignored; the findings may allow indirect inferences in terms of sustainability and adaptive water management. A broader synthesis can be made in the context of sustainability and adaptive management in further research. However, even if these issues are not directly addressed in the current study, the data presented can shed light on such discussions.

From an environmental perspective, it is vital to monitor the impacts of the pond on the ecosystem closely and implement necessary conservation measures. To safeguard aquatic life and maintain the natural balance in the region, environmental impact assessments should be updated regularly, and a water management policy compatible with the ecosystem should be developed. Ultimately, this study advances knowledge in environmental hydrology and climatology, contributing to the development of strategic approaches for water management and climate change adaptation at the regional level.

Declaration of Conflict of Interests

The author declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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