

Impact of Climate Change and Global Warming on Water Management

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Abstract – Global climate change and related water crises are one of the most important problems of our age that many countries in the world will face. The climate change and global warming phenomena have a significant impact on Türkiye. One of the steps to cope with this crisis is sustainable dam management. In this study changes in dam occupancy rates in Bursa, Balıkesir and Istanbul over the years have been correlated with annual temperature increases, precipitation rates and evaporation rates. While annual temperature and evaporation are increasing in Türkiye, there is no significant change in precipitation. The results indicate that severe water crises are possible if current climate conditions persist. In light of the prevailing conditions, it is critical to give precedence to measures such as evaporation prevention, the development of alternative water sources, and the protection of existing water supplies.

Keywords – Global Climate Change, Dam Management, Water Scarcity, Sustainability, Evaporation

I. INTRODUCTION

The fundamental issue that has confronted the planet in the last century is global climate change. Climate change is a multifaceted issue that affects the whole world and involves several governments. It has significant ecological, environmental, socio-political, and socio-economic consequences [1], [2]. Climate change is characterized by enduring changes in temperature and precipitation patterns, as well as other factors including atmospheric pressure and humidity levels. Furthermore, the irregular weather patterns, the shrinking of global ice sheets, and the resulting increase in sea level are widely acknowledged as significant global and local consequences of climate change [3]–[5]. As to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change is expected to speed up, leading to more frequent and intense severe weather events. This would increase the vulnerability of both people and the built and natural environment to these events [6]. Although changes in precipitation and temperature and sea level rise are the issues that climate change brings to

the agenda, water scarcity, which is affected by these issues, is one of the most important problems that humanity has faced and will face.

An estimated 1.1 billion people worldwide lack access to potable water, according to reports [7]. Access to both water and clean water is crucial. Diminishing water levels pose a threat to the secure availability of water. According to the Safe Drinking Water Foundation (SDWF 2018), 80% of illnesses in developing countries are attributed to the use of contaminated water and the transmission of waterborne illnesses [8]. Water scarcity is a complex problem that affects both health and society. The effects of climate change and rising sea levels have put more strain on global water resources, resulting in greater pressure on human populations. This has led to more regional water crises and significant negative effects on overall well-being [6], [9]. Furthermore, agricultural operations are also affected. Furthermore, water scarcity leads to both regional and global migration, resulting in accelerated depletion of available water resources and significant alterations to the socio-cultural structure of affected regions and nations.

The aforementioned reasons are exactly why effective water resource management is crucial for human life. Dams, first constructed in the Middle East during ancient times, are crucial components of water management systems. They serve as effective means to save, store, and distribute water, enabling humans to control water flow and mitigate the risks associated with water scarcity [10]. The inception of contemporary dams may be traced back to the 1940s. The exponential growth of the population and the resulting increase in water consumption have led to a heightened reliance on dams [10]. Dams have been crucial in the progress of human civilization for millennia, enabling the storage of water for future use, diversion of water for non-river purposes, and harnessing it for energy generation. The primary motivations for dam building include ensuring a consistent supply of freshwater in dry and semi-dry areas, promoting agricultural growth and development, meeting residential water needs, generating energy and power, and controlling floods [11]–[16].

Türkiye is a borderline country in terms of available water due to both its climate zone and being a developing country [17]. Dams are very important especially for countries like Türkiye that are on the border of water crisis. Within the scope of this study, the annual occupancy rates of some dams in Türkiye were compared and their relationship with global climate change was tried to be revealed.

II. MATERIALS AND METHOD

The research focused on the correlation between climate change, water scarcity, and dam occupancy rates in the provinces of Balıkesir, Bursa, and Istanbul [18]–[20]. The selected provinces were chosen from the region with the highest population density in Türkiye. In order to correlate it with dam occupancy rates, annual temperature increase rates, evaporation rates and precipitation rates were obtained from The General Directorate of Meteorology, under the Turkish Ministry of Environment, Urbanization, and Climate Change [21]. All data used in the study were obtained from publicly available sources.

III. RESULTS

Global warming is the gradual rise in the average surface temperature of the earth over a prolonged period of time. This is mostly caused by human activity, specifically the release of greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases. The presence of these gases in the Earth's atmosphere results in the retention of heat, causing the greenhouse effect. Human activities, including the combustion of fossil fuels (coal, oil, and natural gas) for energy, deforestation, industrial operations, agriculture, and other human-induced activities, are the main contributors to the rise in greenhouse gases [22]. One of the main problems related to global warming is the gradual rise in the average temperature of the earth which may lead to a couple of issues such as increase in water evaporation resulting a water scarcity or drought. Figure 1, provided by the The General Directorate of Meteorology, demonstrates a noticeable increase of 0.6°C in Turkey's yearly mean temperature from 1970 to the present. Results should be clear and concise. The most important features and trends in the results should be described but should not interpreted in detail.

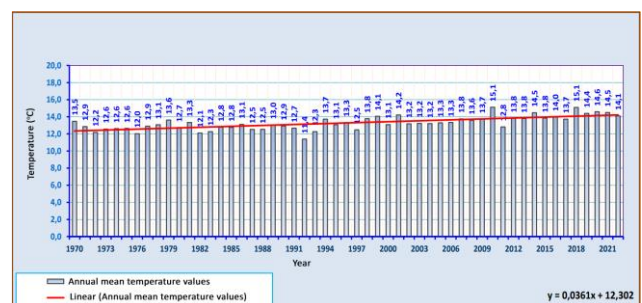


Fig. 1 The annual mean temperature changes in Türkiye from 1971 to 2021 [21]

The elevation in mean temperature results in a corresponding increase in the quantity of water experiencing evaporation. In a study conducted in Australia in 2010, it was stated that open water reservoirs were estimated to lose approximately 40% of their annual total water storage capacity due to evaporation. The primary cause of this loss was identified as elevated surface air temperatures. Furthermore, researchers highlighted that there would be an increase in surface air temperatures and a greater amount of evaporation and water loss in the future [23].

As global warming causes temperatures to increase, the atmosphere experiences a corresponding rise in temperature, resulting in higher rates of evaporation. Increased air temperature leads to an enhanced ability to retain moisture, resulting in greater evaporation from bodies of water and land surfaces. The increased rate of evaporation leads to a greater amount of water vapour in the atmosphere. Elevated levels of water vapour in the atmosphere can result in alterations to precipitation patterns. Increased atmospheric temperature leads to higher moisture retention, which might result in heightened and unpredictable precipitation patterns in certain areas. Consequently, this could lead to increased precipitation, heightened storm severity, or prolonged and intensified droughts in different regions. Furthermore, certain areas may see amplified precipitation and subsequent flooding, while others may confront drought conditions as a result of alterations in precipitation patterns.

As seen in Figures 2 and 3, despite the observed increase in the annual amount of water evaporating in Turkey from 1970 to the present, there hasn't been a noticeable change in the annual average precipitation amount during this period. The anticipated consequence of global warming is an elevation in atmospheric moisture content, however climate models project a far slower rate of precipitation augmentation [24].

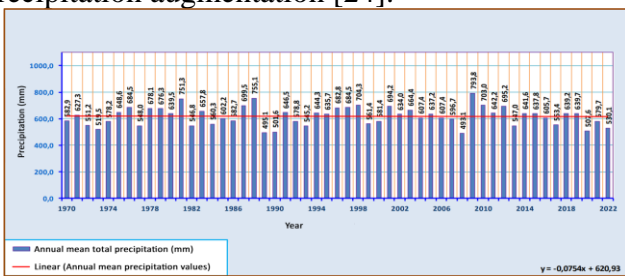


Fig. 2 The annual mean total precipitation changes in Türkiye from 1971 to 2021 [21]

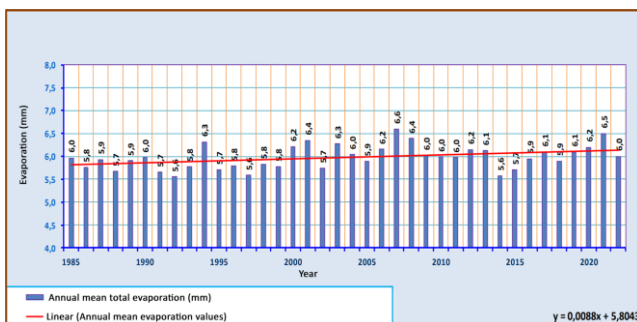
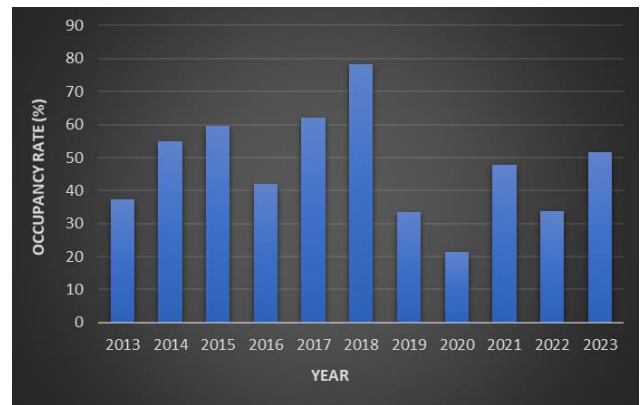
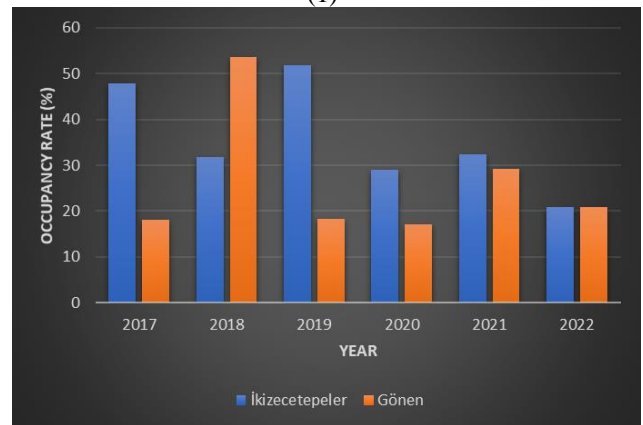


Fig. 3 The annual mean total evaporation changes in Türkiye from 1971 to 2021 [21]

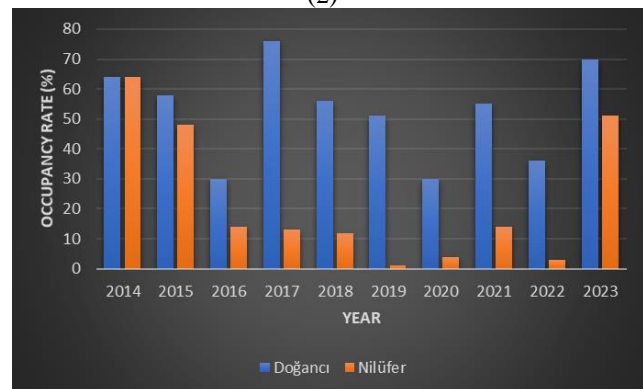
No substantial change in precipitation levels was seen in this research, despite a rise in evaporation rates. Nevertheless, a research analyzing the daily precipitation data collected in Southeastern Spain over the last 75-80 years revealed a decline in annual precipitation levels, ranging from 0% to 15%. Additionally, dry days have become more prolonged, and there has been a fall in the number of wet days. Although evaporation is increasing, the absence of substantial changes in rainfall quantities has a detrimental impact on dam occupancy [25].



(1)



(2)



(3)

Fig. 4 The dam occupancy rate changes of (1) Istanbul [18], (2) Balıkesir [20], (3) Bursa [19] province in december by years

Tracking reservoir filling levels is crucial for managing water resources, especially in evaluating water availability, predicting potential shortages, and ensuring adequate water supply for various purposes like irrigation, drinking water, and hydroelectric power generation. Figure 4 illustrates the yearly changes in the reservoir filling levels in three different provinces of Türkiye (Istanbul, Bursa, Balıkesir). As depicted in the graphs, after reaching a peak in 2018, the reservoir filling levels have declined. The effect of increased evaporation due to rising temperatures, coupled with relatively stable precipitation levels, has led to a gradual decrease in the water quantity available in surface water sources. The 2020 research done in Australia evaluates long-term trends in surface water occurrence and climate variables in a large agricultural catchment of Australia to understand evaporative water losses from open water bodies. It was noticed that when temperatures increased in the basin, there was less rainfall and lower humidity. This led to an increase in evaporation inside the basin [26].

IV. DISCUSSION

Accessing sufficient amounts and quality fresh water is becoming progressively more challenging due to climate change, global warming, population growth, and industrial activities. As a consequence of climate change, precipitation exhibits irregularities, which cause precipitation that was anticipated to transpire over an extended period of time to transpire prematurely. Global warming has the effect of increasing evaporation. Population growth and industrialization are factors that contribute to the increasing demand for water. The issue of insufficient and sanitary water supply is persistently escalating in several nations. Despite the absence of a rise in water resources, the surge in water demand necessitates the implementation of additional measures to ensure water security. Water storage facilities such as dams not only give advantages such as stable water supply, flood control and good water quality, growth of irrigated agriculture, rise in groundwater level and increase in revenue, but also provide enormous surface areas for water evaporation. The climate change and global warming phenomena have a significant impact on Türkiye. Intense rainfall over a short period of time may cause catastrophes, and it is often not feasible for the excess rainwater to seep

into the earth or be stored in buildings like dams. Within the scope of this study, recommendations for sustainable water management within the scope of combating climate change and water scarcity are given below.

1- In the state of California, in order to reduce evaporation in water storage structures such as dams, the surfaces of the water storage reservoir are covered (Example: Covering the water surface with black balls). Measures can be taken to reduce evaporation in water accumulation structures with large surface areas in Türkiye [27]–[29].

2- The quantity of subterranean reservoirs with limited surface areas, where evaporation will be reduced, may be augmented.

3- Domestic wastewater can be treated and reused in agricultural irrigation, landscaping and similar areas where water use is common. Thus, it can contribute to the protection of fresh water reserves.

4- Storage dams, constructed across riverbeds to prevent sedimentation from rainfall basins from reaching downstream areas, and similar structures should be built upstream of water accumulation structures to prevent debris from reaching the accumulation site. This ensures that the effective capacity of water accumulation structures can be fully utilized [30].

V. CONCLUSION

Publicly available data indicates that Türkiye has seen the impacts of climate change and drought in recent years. Developing countries such as Türkiye must address the water issue, a significant consequence of climate change, in a comprehensive way. The significance of sustainable dam management lies in its crucial role in ensuring long-term environmental and socio-economic stability. Given the circumstances, it is imperative to prioritize the prevention of evaporation, the establishment of alternative water sources, and the safeguarding of current water supplies.

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