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Climate Change Impacts and the Importance of Integrated Water Management

Ertan Karahanlı[1*], Cengiz Mutlu[2]

Abstract: Persistent changes in weather patterns on a worldwide scale are a hallmark of climate change, which has significant effects on water supplies. Extreme weather events, altered precipitation patterns, and rising temperatures pose a hazard to the quantity and quality of water supplies. In this regard, droughts seriously disturb water supply networks, which lowers agricultural output and jeopardizes the health of ecosystems. Water resources are reduced as a result of droughts, which have an especially negative effect on industry, agriculture, and the availability of drinking water. Climate change and the growing frequency of drought occurrences underscore the need for creative and sustainable water management strategies. In this regard, an essential framework for the efficient and sustainable use of water resources is offered by integrated water resources management, or IWRM. The goal of IWRM is to balance various water usage needs while preserving the biological system by implementing a multidisciplinary approach to water resources management. The rise in drought episodes serves as an example of how climate change is affecting water resources, and the function of integrated water resources management (IWRM) in this process is explored. According to the study's findings, IWRM techniques can help people and ecosystems become more resilient while facilitating more effective use of water resources during dry spells. As a result, it is stressed how crucial integrated water resources management is to combating climate change.

Key words: Drought, climate change, integrated, water resources

İklim Değişikliğinin Etkileri ve Entegre Su Yönetiminin Önemi

Özet: Dünya ölçeğinde hava modellerindeki kalıcı değişiklikler, su kaynakları üzerinde önemli etkileri olan iklim değişikliğinin ayırt edici bir özelliğidir. Aşırı hava olayları, değişen yağış modelleri ve artan sıcaklıklar su kaynaklarının miktarı ve kalitesi için tehlike oluşturmaktadır. Bu bağlamda, kuraklıklar su tedarik ağlarını ciddi şekilde bozarak tarımsal üretimi azaltmakta ve ekosistemlerin sağlığını tehlikeye atmaktadır. Özellikle sanayi, tarım ve içme suyu mevcudiyeti üzerinde olumsuz etkileri olan kuraklıklar sonucunda su kaynakları azalmaktadır. İklim değişikliği ve kuraklık olaylarının artan sıklığı, yaratıcı ve sürdürülebilir su yönetimi stratejilerine duyulan ihtiyacın altını çizmektedir. Bu bağlamda, su kaynaklarının verimli ve sürdürülebilir kullanımı için temel bir çerçeve entegre su kaynakları yönetimi veya IWRM tarafından sunulmaktadır. IWRM'nin amacı, su kaynakları yönetimine multidisipliner bir yaklaşım uygulayarak biyolojik sistemi korurken çeşitli su kullanım ihtiyaçlarını dengelemektir. Kuraklık dönemlerindeki artış, iklim değişikliğinin su kaynaklarını nasıl etkilediğine bir örnek teşkil etmekte ve entegre su kaynakları yönetiminin (IWRM) bu süreçteki işlevi araştırılmaktadır. Çalışmanın bulgularına göre, IWRM teknikleri insanların ve ekosistemlerin daha dirençli hale gelmesine yardımcı olurken, kurak dönemlerde su kaynaklarının daha etkin kullanımını kolaylaştırabilir. Sonuç olarak, entegre su kaynakları yönetiminin iklim değişikliğiyle mücadelede ne kadar önemli olduğu vurgulanmaktadır.

Anahtar kelimeler: Kuraklık, iklim değişikliği, entegre, su kaynakları

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1. Introduction

A few people in the water profession began to understand in the early 1980s that the situation regarding water globally was not as favorable as it seemed. This sentiment became more intense in the 1990s as more professionals in the field realized that the water issues had become multifaceted, multisectoral, and multiregional, intertwined with multiple agendas, interests, and causes, and that only proper multidisciplinary, multi-institutional, and multi-stakeholder coordination could resolve them. But right now, the more important question is not whether such a process is desirable, but rather, is it feasible to implement it in a timely, economical, and socially acceptable way in the actual world (Mayaux & Fernandez, 2024). A worldwide solution to the problem was introduced at the United Nations World Summit Conference on Environment and Development in Rio de Janeiro in 1992, which also envisioned integrating environmental concerns with social and economic decision-making. Agenda 21 is the name of the declaration that announced the decisions made in Rio. In order to ensure environmental protection and sustainable development, this declaration, which serves as an action plan for both 1990 and the twenty-first century, calls for the adoption of efficient resource management plans with integrated methods and strategies in every nation. Water resources must be viewed in the context of the entire environment, and resource management must be done on a basin-by-basin basis and "integrated" with other natural resources, according to the declaration (Duda & Hirji, 2025).

Prior to 2000, the countries that make up the European Union frequently had highly complicated water resource management. Diverse and sometimes incoherent strategies were employed by member states to safeguard the environment and water quality. More than ten European countries receive half of their entire water supplies from nearby nations. In spite of this, transboundary waterways and contaminants lacked a common control (Adamopoulos et al., 2024).

The European Union's current state of water resources and water management; The European Union, which is fortunate to have abundant water resources, lacks drinking water. Serious water issues like floods and droughts have not affected the EU. In spite of this, Europe's water management and quality are in poor condition: Severe pollution poses a hazard to twenty percent of the surface water in the European Union (Jam, 2025). Drinking water accounts for 65% of groundwater resources in Europe. The groundwater supplies in 60% of European cities are overused. Since 1985, the area under irrigation in southern Europe has grown by 20% (Elmadani, 2024).

There are more than twenty directives in the European Union legislation. The most important among these directives is the “Water Framework Directive” dated October 23, 2000 and numbered 2000/60/EC.

A new strategy is introduced by the Water Framework Directive (WFD), which has the following key components.

- It safeguards groundwater, rivers, lakes, and coastal waterways.
- It establishes a strict goal that by 2015, all bodies of water must be in "good status."
- It necessitates management based on river basins, where political boundaries do not restrict water systems.
- It presents a comprehensive strategy for quality standards and emission limit values.
- It necessitates a participatory strategy that involves the public and civil society organizations in water management initiatives.
- It necessitates the mitigation and management of pollution from home, industrial, agricultural, and other sources.
- Water pricing is necessary, and the polluter pays concept must be applied with the appropriate fees.
- It seeks to achieve equilibrium between those who rely on the environment and those who rely on it.

The implementation of a single water resources management system known as "river basin management" is one of the most significant aspects of the SEA. As a result, rather than using administrative or political borders to divide resources, "river basin regions" will be established based on natural geographic and hydrological factors. The knowledge that underpinned the issues addressed began with river basin management and has since been updated to include integrated basin management and integrated water resources management. It is still in effect today (Tapas et al., 2024).

2. Methodology

This study is a literature review that aims to present current knowledge on the impacts of global warming and the importance of water management. National and international databases (Web of Science, Scopus, ScienceDirect, SpringerLink, Google Scholar, TR Index) were searched for the study, using keywords such as "global warming," "climate change," "water management," "sustainable water resources," "global warming," "climate change," "water management," and "sustainable water resources." Studies between the years 2000 and 2025 were primarily examined in the search, but older, significant studies that contributed to the conceptual framework were also included. Inclusion criteria were direct relevance to global warming and water management, academic quality, and full-text accessibility. The obtained resources were evaluated through content analysis, and the findings were categorized and presented under the following headings: the effects of global warming on water resources, water security, agricultural and industrial implications, and sustainable water management strategies.

2.1. Distribution of available water by sectors

Despite the fact that water covers three quarters of the Earth's surface, there is very little freshwater accessible to humans. Figure 1 illustrates that of the approximately 35 million km3 (or 2.5% of Earth's total water volume) of freshwater, only approximately 105,000 km3 (or 0.3% of the total) are available for use by ecosystems and humans. The majority of the freshwater that remains is frozen and stored underground in high mountains and glaciers at the poles (Muluk et al., 2014).

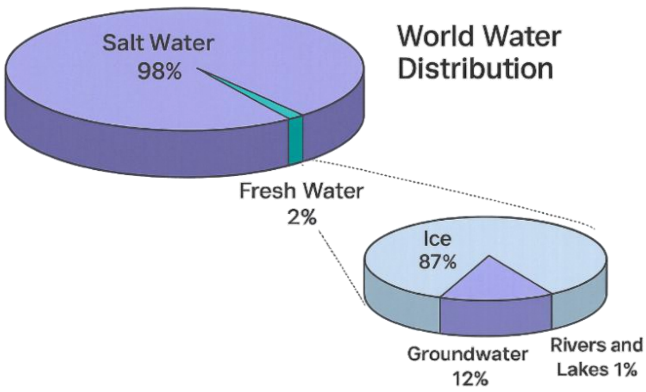

Figure 1. World water distribution (Gleick, 1996)

One of the main causes of the rise in drought occurrences globally is climate change. Increased evaporation rates, erratic precipitation patterns, and rising temperatures put significant strain on water and agricultural resources in particular. Due to decreased agricultural land productivity and more challenging water supply, drought endangers both natural ecosystems and food security. Particularly in areas with poor water supplies, this condition exacerbates social and economic issues and has detrimental effects like poverty and migration. Global sustainability so depends on creating plans to address drought and fight climate change (Li, 2024).

An examination of water usage rates between 2010 and 2020 reveals that agricultural irrigation accounts for the majority of Turkey's total water consumption, varying between 70% and 77% over the years. Water consumption for drinking, domestic, and industrial purposes, however, remained relatively low, reaching a peak of 29.2% in 2014 at 23.6% in 2010 and declining to 23.2% in 2020. This demonstrates the decisive role agricultural irrigation plays in water resource management, and the critical importance of modern irrigation techniques and effective water management policies for sustainability (Figure 2).

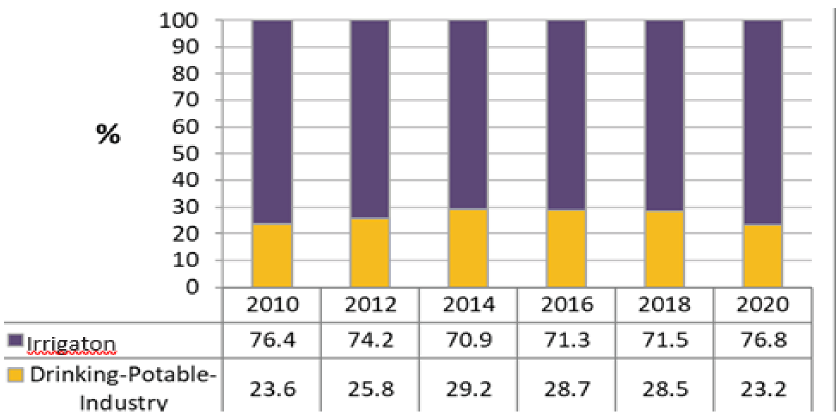

Figure 2. Distribution of available water to the sectors

There is a limited quantity of useable water in surface streams and ponds due to the world's extremely diverse distribution of water resources, which includes the majority of freshwater found in lakes, glaciers, and groundwater sources. Freshwater makes up over 2.5% of the world's water supply, although just 1% of it is directly usable by humans. Furthermore, the availability of water resources is threatened by elements like pollution, population increase, and climate change, which makes equitable water sharing challenging. The distribution of water at the regional and national levels is crucial for social fairness and economic growth, particularly in areas with limited water resources (Sharma, 2024).

Given geographical variations and meteorological circumstances, the world's yearly water consumption per person has emerged as a crucial metric. Globally, the typical person uses 7.5 thousand liters of fresh water per year as of 2023. This number, however, differs greatly between nations. For instance, this amount can be as much as 20,000 liters in nations with plenty of water, while it might be less than 1,000 liters in areas with little water. This circumstance demonstrates that water is not just a physical resource but also a source of social, political, and economic issues (Jain and Singh, 2023).

An examination of countries' annual per capita water consumption reveals that the United States has the highest consumption at 1,583 m³, followed by Estonia (1,227 m³), New Zealand (1,191 m³), and Canada (1,025 m³). Among European countries, Spain (809 m³) stands out with its high consumption, while Turkey, with 642 m³, falls into the upper-middle category, exhibiting a value above the global average. Conversely, per capita water consumption remains lower in countries such as Germany (404 m³), France (472 m³), and Poland (295 m³), while the lowest values were recorded in Luxembourg (80 m³), Denmark (117 m³), and the United Kingdom (129 m³). These differences reveal that countries' access to water resources, their economic structures, agricultural and industrial activities, and consumption habits play a significant role in determining per capita water use (Figure 3).

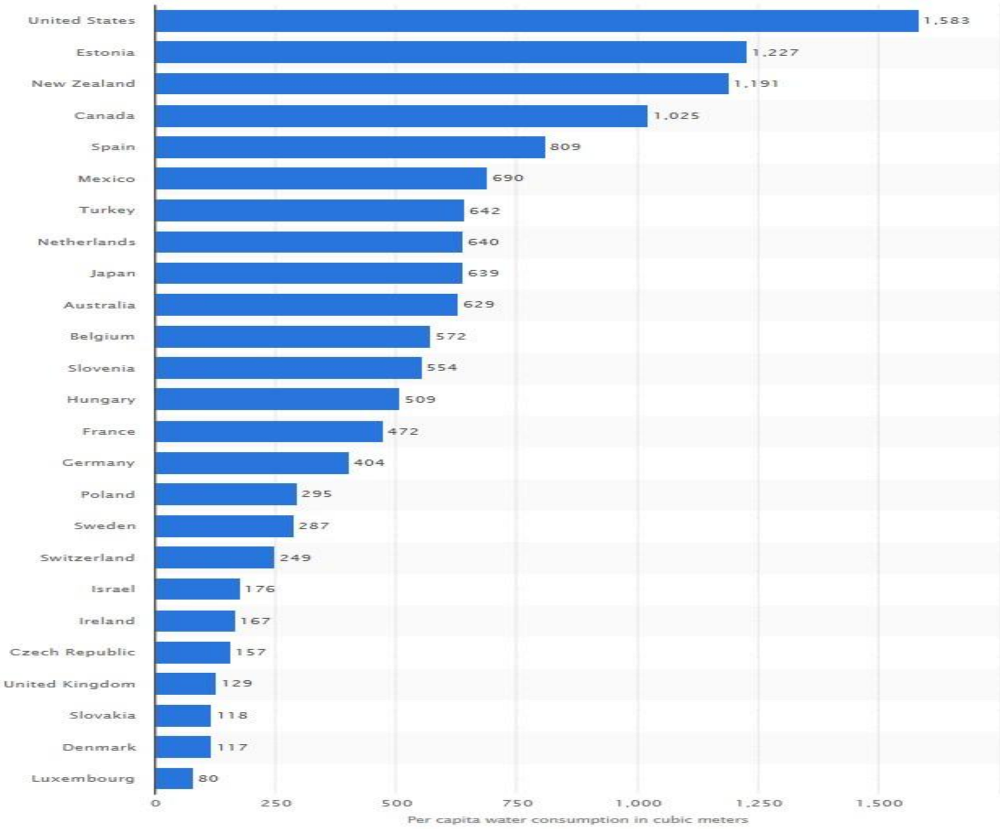

Figure 3. per capita water consumption in cubic meter (World Resources, 2001)

The amount of water per capita is also impacted by population increase, industrial water usage, and agricultural water use. The sustainability of water supplies is also threatened by climate change and global warming. Social disparities in access to clean water are prevalent, and many nations struggle to manage their water resources effectively (Jain et al., 2024).

Understanding the past development of water security technology is crucial to comprehending the current and next water security concepts (Figure 4). New approaches were needed in urban settings to deal with the stages of changing water needs as urban areas grew. Due to a number of circumstances, the idea of water supply for demand management in urban water systems developed and shifted toward water-sensitive cities (Varma et al., 2024). This water transition phase is caused by a number of factors, including fast population increase and water-intensive use practices. It is crucial to alter the management approach that emerges in response to social and political considerations in order to address the growing issue of water security (Brown et al. 2008).

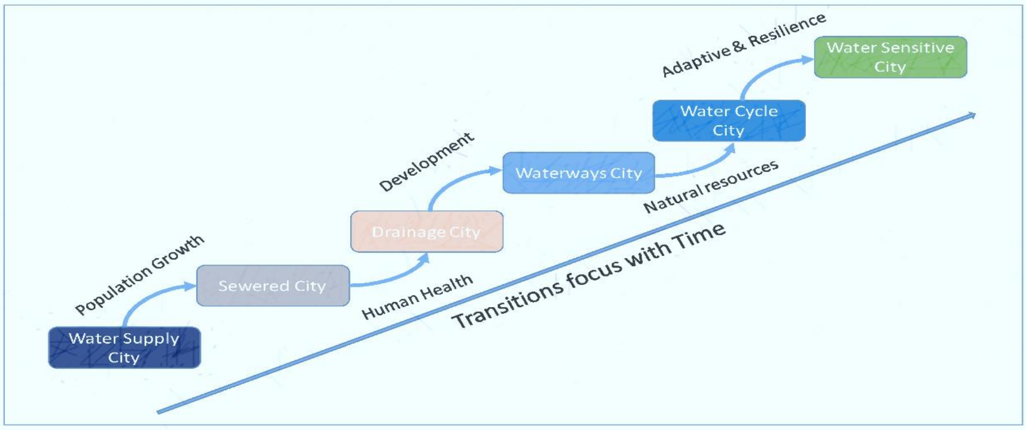

Figure 4. Changing paradigms of Water Security and Transition Phase for cities (adapted from brown et al. 2008)

The proper operation of freshwater (riverine) ecosystems is essential to the provision of freshwater. Studies that take into account whole ecosystems, such a river, are rare, nevertheless (O'Brien et al. 2016). A significant obstacle to sustainable water resource management is the significant anthropogenic alteration of the majority of riverine systems, which leaves out essential "pieces" or functions related to ecosystem variety that are necessary to provide sustainable solutions. Since freshwater ecosystems are frequently heavily designed, it is possible for them to lack important components of ecosystem variety, which is a typical occurrence that eventually causes the freshwater systems to lose their resilience (Bănăduc, 2024).

Therefore, the yearly amount of water per capita has a direct impact on people's quality of life, and it is crucial to strengthen international cooperation for sustainable water management, water resource preservation, and equitable distribution. In addition to being a source of life, water is essential for both social fairness and economic growth (Han, 2024).

Compared to the 1850–1900 reference period, global temperatures fluctuated until the mid-20th century, entering a significant upward trend, particularly after 1950. The acceleration accelerated after 1980, and from 2000 onward, the temperature difference exceeded 1°C. By 2023, the global temperature difference approached 1.4°C, reaching the highest level in modern climate records. All data sets show similar trends, and despite minor differences, the upward trend appears consistent (Figure 5).

Global climate change: water and drought

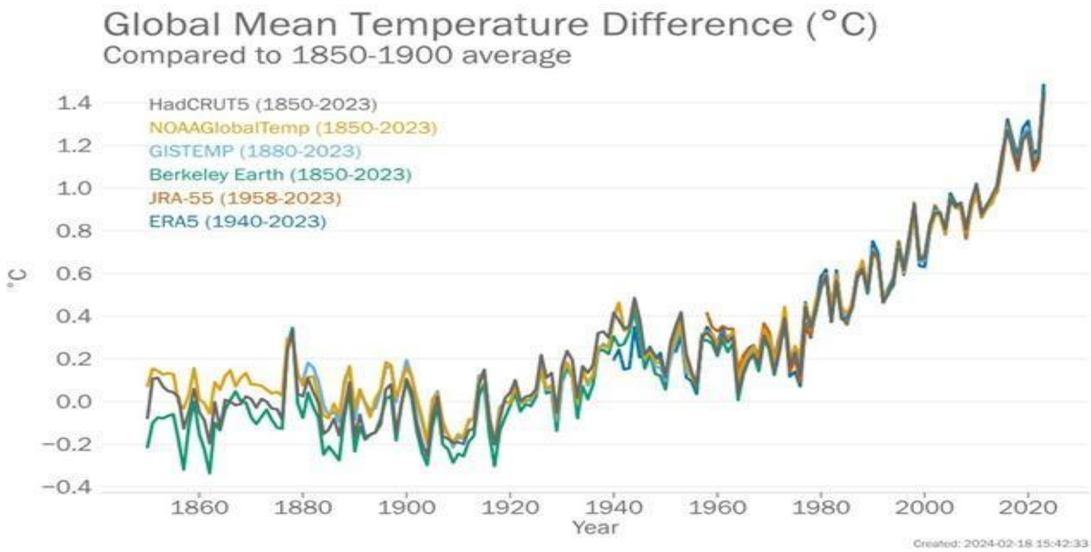

Figure 5. Global elimate change, water and drought (WMO, 2023)

In the year 2023, the average global near-surface temperature was 1.45 ± 0.12 °C higher than the pre-industrial average of 1850–1900. In the 174-year observational record, 2023 was the hottest year on record. This broke the previous warmest year record of 1.29 ± 0.12 °C above the 1850–1900 average in 2016 and 1.27 ± 0.13 °C above the 1850–1900 average in 2024 (Dunstone, 2024).

An examination of marine heatwave (MHW) data for 2023 reveals that more than half of the world's oceans remained under MHW conditions of varying intensities throughout the year, with severe and extreme events particularly concentrated in regions such as the North Atlantic, Northeast Pacific, Indian Ocean, and the Mediterranean Sea. Daily averages indicate that 40–60% of the ocean surface was affected by MHW, with cumulative impacts exceeding 60 days by the end of the year. Compared to the 1980s, both the extent and intensity of marine heatwaves have increased significantly, becoming much more common compared to normal conditions, particularly in the post-2000 period. A) Marine heatwaves (DHW) were observed to spread over extremely large areas globally in 2023, particularly in tropical and mid-latitude regions. B) The proportion of ocean surface covered by marine heatwaves gradually increased throughout the year, reaching 40-60%. C) The average number of DHW days increased cumulatively throughout the year and exceeded 60 days by the end of 2023. D) The long-term trend from 1984 to 2023 shows that DHW coverage worldwide increased and reached higher levels, particularly in the previous 20 years (Figure 6). These findings clearly demonstrate the pressures of climate change on marine ecosystems and demonstrate that they pose serious global risks to fisheries, coral reefs, biodiversity, and food security.

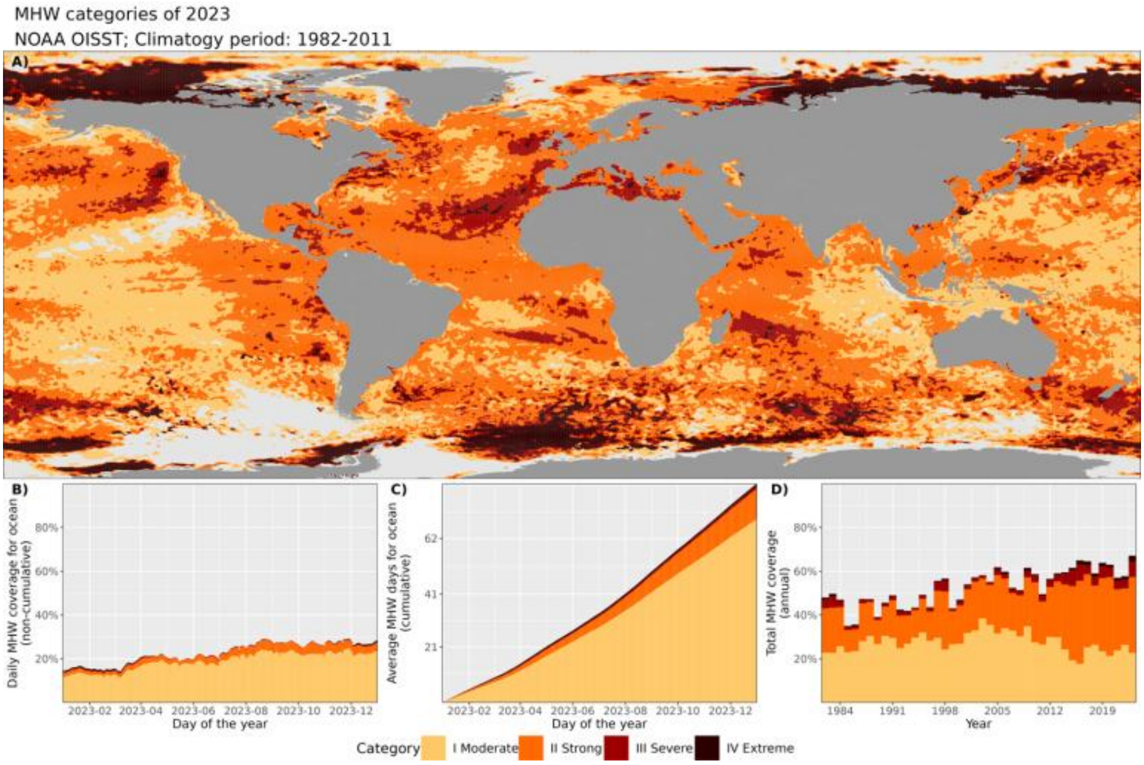

Figure 6. the average global near-surface temperature in the year 2023- State of the Global Climate 2023 report (WMO, 2023)

Global map displaying, for the reference period of 1982–2011, the maximum Marine Heatwave category in each pixel over 2023. A comprehensive statistical study indicates that in 2023, ocean heat content peaked. The last 20 years have seen an especially significant increase in warming rates. Warming is predicted to continue, marking an irreversible shift over hundreds to thousands of years (Espinosa and Portela, 2025).

According to UN estimates, global water usage might rise by 40% by 2025 compared to 2015. Factors like population growth and shifting dietary patterns are to blame for this surge. Water consumption will rise as living standards rise in emerging nations, which will lead to a higher uptake of Western lifestyles. According to UNESCO, people in developed nations consume almost 10 times as much water per day as those in underdeveloped nations.

Around 70% of the water used worldwide is used for agriculture, making it the greatest consumer of water. Water usage is expected to rise in tandem with the population growth and the corresponding rise in food demand.

Effective water management techniques must be developed in order to solve this issue. Promoting novel farming techniques is crucial for improving people's sustainable consumption patterns and water usage efficiency. Technology advancements and awareness-raising educational initiatives should be key components in lowering the rise in water demand (Kolahi, 2024).

Co-operation between governments, businesses and communities is vital for the development and implementation of solutions to ensure water security. Proactively addressing these challenges is essential to ensure the sustainability of water resources for future generations.

2.1.1. Precipitation

In our nation, there is 642.6 mm of precipitation on average every year, or 501 billion m3 of water. Eleven2 billion m3 of surface and subsurface water may be used, both economically and technically. A supply of 95 billion m3 from domestic rivers, 3 billion m3 from foreign rivers, and 14 billion m3 from groundwater are expected to meet this requirement. The yearly water potential also varies significantly on a basin level (Figure 7).

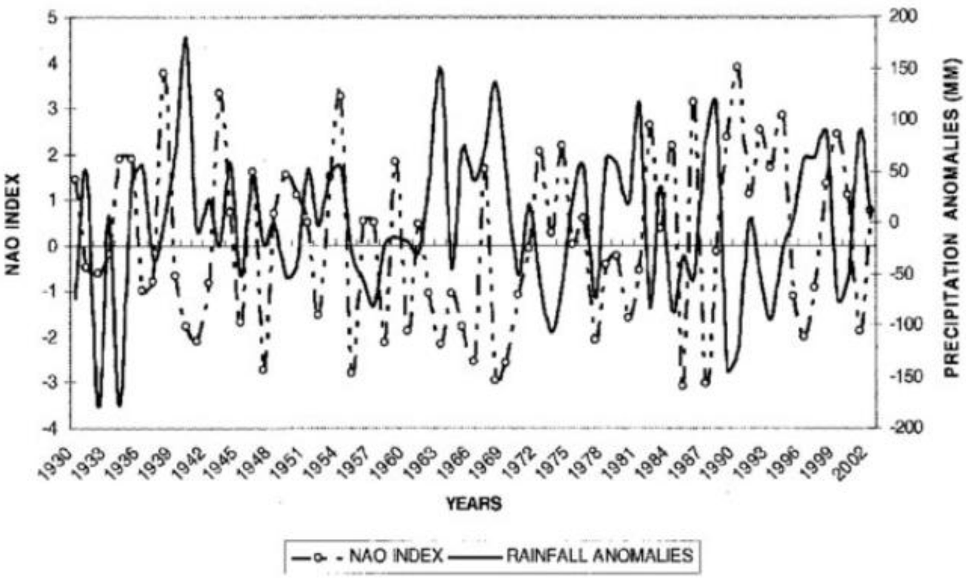

Figure 7. Türkiye Precipitation Anomaly (Sönmez et al., 2005).

46 billion m3 of water were used in our nation by the end of 2008; 34 billion m3 were used for irrigation, 7 billion m3 for drinking water, and 5 billion m3 for industry. This amount is equivalent to 41% of the 112 billion m3 of accessible water potential. By 2023, Turkey hopes to have utilized every one of its 112 billion m3 of commercially useable water. Building treatment facilities is necessary in order to reuse wastewater.

As Turkey's population grew from 67 803 927 to 72 561 312 in 2009, the country's water per capita dropped from 1652 m3 in 2000 to 1544 m3 in 2009 (Figure 1; Aküzüm et al., 2010).

By 2023, Turkey's fast expanding tourist industry is predicted to need 5 billion m³ of water a year. As a result, it is anticipated that 18 billion m³ of drinking and potable water would be consumed worldwide in 2023 (Özkan, 2024). The entire industrial water consumption in 2023 will be 22 billion m³ if the industrial sector's 4% annual growth rate holds true (Figure 8).

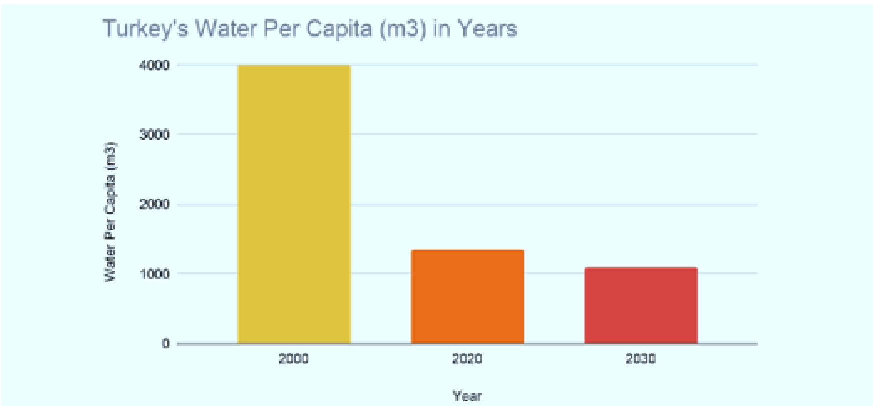

Figure 8. Türkiye's Water Per Capita in Different Years

Desertification is the loss of soil productivity, a non-renewable resource, rather than the conversion of an area into a desert. The loss of soils due to wind and water erosion, the deterioration of the physical, chemical, and biological characteristics of soils, the ensuing financial losses, and the long-term loss of plant cover are all considered forms of land degradation. In addition to agricultural regions, steppes, pastures, woodlands, and maquis/moorland are also affected by the process of soil degradation (Türkes, 2012).

In addition to agricultural regions, steppes, pastures, woodlands, and maquis/moorland are also affected by the process of soil degradation. Natural occurrences like floods, droughts, and fires; loss of soil organic matter, concretization of soils, degradation of soils, and pollution of soils are all detrimental effects of human activities like deforestation, overgrazing of pastures beyond their capacity, incorrect and improper land use, overproduction in agricultural areas, and excessive fertilization and spraying for this purpose, burning of stubble, excessive and careless irrigation, and industrial wastes (Türkes, 2012)

According to Figure 9, 12-month SPI drought analysis covering the period 1981–2020 shows that Turkey experienced dry and humid periods of varying severity starting in December. Eleven of the 40 years analyzed were identified as dry years, with 2008 standing out as the driest. According to the data, although Turkey occasionally experiences "very humid" and "excessively humid" periods, the frequency of drought years is striking. Severe droughts were observed in years such as 1989, 1990, 2008, and 2014, while years such as 1983, 1995, 2009, and 2015 stand out as extremely humid periods. These findings demonstrate that Turkey experiences significant fluctuations in its hydroclimatic conditions, that the risk of drought persists, and that integrated and sustainable approaches to water resources management are needed. 1) Bar Graph (1981–2020): This graph shows the Standard Precipitation Index (SPI) values of each year; wet periods are shown with positive values (green/purple shades) and dry periods are shown with negative values (orange/brown shades). Unlike 1988 and 2009, which experienced extreme precipitation, the years 1990 and 2008 were marked by extreme drought. 1) Bar Graph (1981–2020): This graph shows the Standard Precipitation Index (SPI) values of each year; wet periods are shown with positive values (green/purple shades) and dry periods are shown with negative values (orange/brown shades). Unlike 1988 and 2009, which experienced extreme precipitation, the years 1990 and 2008 were marked by extreme drought. 3) Percentage Distribution Pie Chart: It shows the percentage distribution of the periods observed over the 40-year period. Normal rainfall is limited to the "mild drought" and "moderately wet" categories of significant proportions. Exceptionally wet or extremely dry conditions (extremes) occurred at very low rates (around 2.5%) (Figure 9).

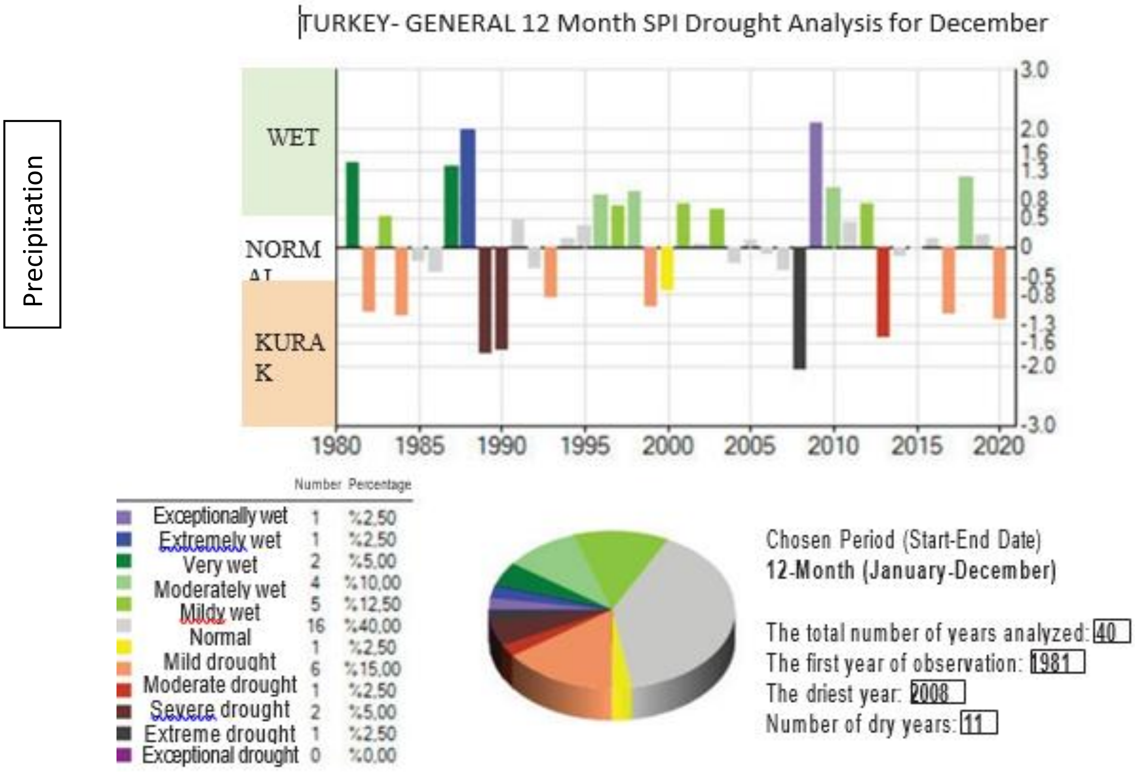

Figure 9. Drough Analysis for December in Türkiye

Source: The Ministry of Environment, Urbanisation and Climate Change, Turkish State Meteorological Service; 2021

An examination of annual average temperature trends over the period 1971–2020 reveals that temperatures have shown a steady and regular increase globally, while in Turkey, while fluctuating, they have exhibited a significant upward trend, particularly since the 1990s. The global average rose from approximately 13.5°C in the 1970s to around 14.8°C by 2020. Despite experiencing periods of cooling, the Turkish average has increased rapidly since the 2000s, converging with the global average since 2010. These fluctuating but sharp jumps in Turkey's temperature increase reveal that the country is more vulnerable to climate change and may experience the effects of extreme climate events more severely than the global average (Figure 10).

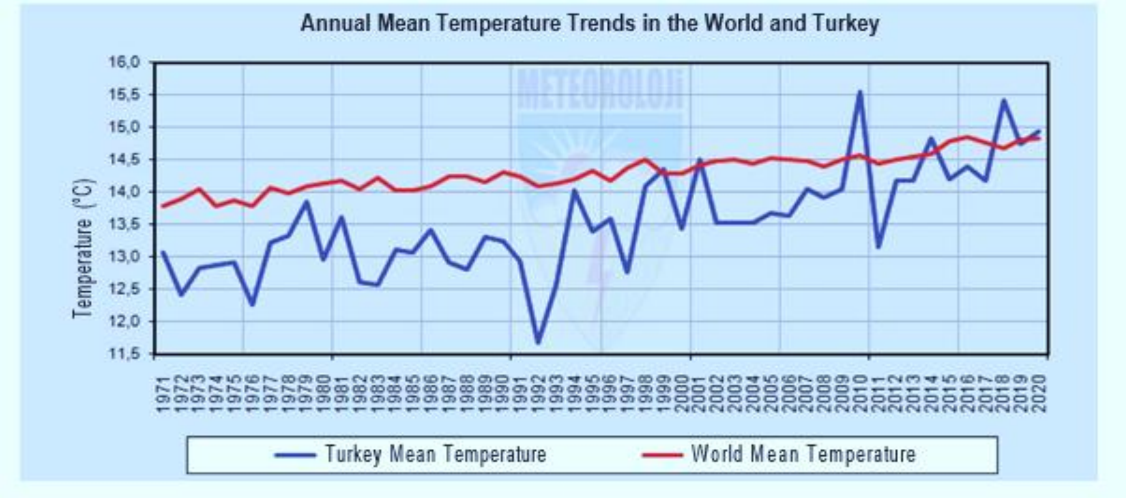

Figure 10. Annual mean temperature trend in the world and Türkiye (Turkish State Meteorological Service, 2021).

In some periods, temperature averages in Turkey catch up with global averages, while in others they exceed them. This indicates that Turkey will face the threat of drought in the future.

For the years 2016–2099, the General Directorate of Meteorology has created climate forecasts using three distinct global models to show how climate change may impact our nation in the future. The study obtained projection results for Turkey and its region with 20 km resolution for the reference period 1971-2000, future periods 2016-2040, 2041-2070, 2071-2099, and future periods 2016-2040, 2041-2070, 2071-2099 according to RCP4.5 and RCP8.5 scenarios by using a dynamic downscaling method with the RegCM4.3.4 Regional Model. The datasets used in the study were HadGEM2-ES, MPI-ESM-MR, and GFDL-ESM2M global model datasets (Kim et al., 2024).

The changes between 1971 and 2018 are shown in Figure 11. Future predictions are being studied in subsequent studies. According to the results we obtained from the projections of 3 global models, the average temperature increase across the country for the period 2016-2099.

Turkey's average annual mean temperature is predicted to rise by 1.5–2.6°C on average between 2016 and 2099, based on the RCP4.5 scenario. In the first half of the century, average annual temperatures are expected to rise by an average of 1.4°C and the average temperature anomaly is predicted to be between-0.9 and 4.1°C; in the second half of the century, average annual temperatures are expected to rise by an average of 2.2°C and range from 0.6 to 4.1°C (Türkeş & Yurtseven, 2025).

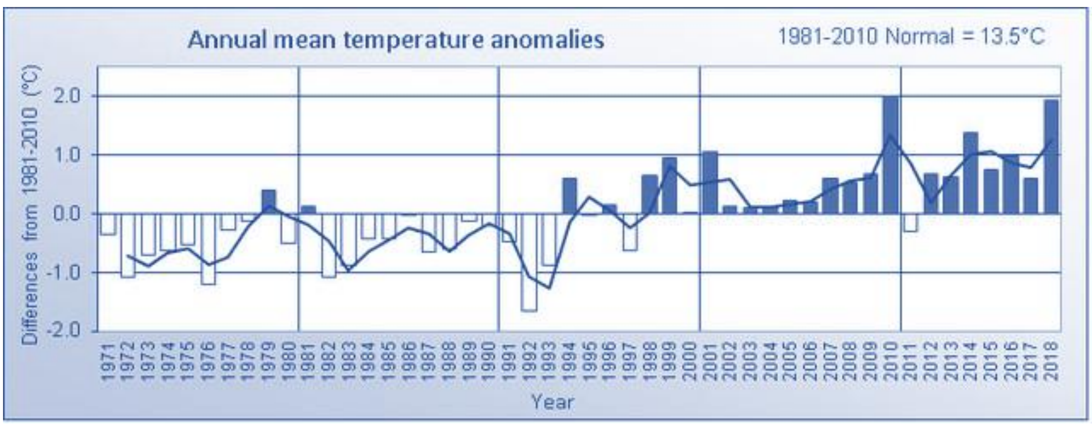

Figure 11. Range Of Change in The Annual Average Temperature Anomaly of Türkiye

While rainwater harvesting systems are used in many countries around the world, it cannot be said that our country, which is in the category of water scarce countries, has made sufficient progress in this field. It is known that many of the solutions we use in our traditional buildings involve collecting rainwater in the right seasons and using it when needed. There are undoubtedly water wells around old buildings. In addition to water wells, cisterns are also frequently used in traditional houses to collect rainwater. Both in-building and regional rainwater management are part of the rainwater approach. Water consumption can be reduced through larger-scale water harvesting methods, agricultural irrigation and regional rainfall management (Tanık, 2017).

3. Basin Management

It is referred to as the point in river basins where water flows from the border (separation) line to the sea, and in closed basins, it is referred to as the water collection area based on the point at which water is finally collected. Stated differently, it is a specific area of land with a specific size that is split by a river, has distinct natural resources, is encircled by hills and mountains, and whose waters empty into the same lake, river, or sea (Yazıcı, 2019). The importance of basin-based water resources management has grown despite the growing demand for water brought on by the world's population growth. This is because resources are scarce and overuse and pollution from expanding industrial and agricultural activities have also contributed to this problem (Demirel, 2021).

3.1. Effective Management

It is defined as the process of coordinating all kinds of activities to effectively and efficiently achieve goals and objectives set with and through others (Rubbins and Coulter, 2003: 6). Effective management requires the inclusion of all parties in close relationship with the field, known as stakeholders. Individuals who are informed, involved and empowered will make better choices for themselves; managers and decision makers will also help them make better choices (ÇOB, 2007).

3.2. Integrated basin management

When planning integrated water resources management, it would be more appropriate to plan on a basin basis. First of all, it is useful to take a look at what watershed management is and what its benefits are. The process of coordinated planning, managing, and carrying out various activities to guarantee the sustainable use of natural resources in the basin while taking into consideration the presence of social, political, economic, and institutional factors within the basin is known as integrated basin management, or IBM. As a result, ESM guarantees efficient and consistent cooperation for the preservation and sustainable use of watersheds (Liu et al., 2024).

3.2.1. The Reasons Behind The Emergence Of The İntegrated Management Concept

Water resources planning's primary goals up until the middle of the 1970s were resource development for this purpose, water supply to satisfy a specific need, and system design to stop water damage. The factor that needed to be ascertained in order to accomplish these goals was the available water potential, or, to put it more broadly, the volume of water. Diversification of aims and solutions available for planning has led to a shift over time from single-purpose planning to multipurpose projects for more efficient use of water resources, which are becoming scarce. The growth of water resources has given rise to the validity of optimization methodologies within this framework (Cardona-Almeida and Suárez, 2024).

Water resources were the natural resources most severely impacted by environmental contamination issues that surfaced in the 1980s. The amount of viable water resources is beginning to decrease due to the degradation of the water quality. It has not been too difficult to identify and address the pollution loads discharged pointwise into the river in the studies conducted for the control of water pollution (Sharma, 2024).

However, other significant events that contributed to the global "environmental crisis" started to become apparent in the 1980s. For instance, there are numerous regions of the world experiencing rapid urbanization and population increase, along with the related issues of hunger, water scarcity, and waste management (Williamson, 2025).

Growing industrial expansion has led to issues with water contamination, hazardous waste, and poisonous chemicals. While the topic of global climate change is being discussed, the ozone layer is also being harmed (Feng, 2024).

In the latter part of the 1980s, the issue of global warming has come to light. Due to this issue, it is anticipated that issues like drought, starvation brought on by crop failure, and desertification would worsen; also, the disturbance of the hydrological balance will cause an increase in floods and droughts, which will have detrimental socioeconomic effects.

The only planet that has lakes and rivers, where life is supported by the water cycle, is Earth. There is about 1.4 billion m3 of water in the hydrosphere, a layer of the Earth. Nevertheless, 97% of this enormous volume of water is

salinized and unusable for people. About 2.5 percent of the water on Earth is freshwater, and at the poles, two thirds of this water exists as ice. Lakes, rivers, and springs contain the remaining one-third of the freshwater available. However, because they include substances like arsenic, some of these waters are unsafe to consume (Kılıç, 2011).
While the allotment of water for irrigation was once prioritized in semi-arid nations like ours, the need for drinking, potable water, and industrial water is progressively growing nowadays in tandem with rapid population expansion and industrial development. IWMI (1999) anticipated that the following sectors will see the greatest rise in water demand between 1995 and 2025:

- Potable and drinking water: 84
- 60% of industrial water
- 17% in agriculture
- Future projections are also shown in figüre 12.

1) Agriculture: Agricultural water use has increased rapidly from the 1900s to the present, accelerating particularly after 1950, reaching levels of 2,500–3,000 km³/year in the 2000s. The largest difference between water extraction and consumption is seen in agriculture, meaning irreversible losses in irrigation are very high. Projections to 2025 also indicate that agriculture will continue to be the dominant sector in global water consumption (Figure 12).

2) Domestic use: Domestic water use was very low in 1900, but has risen rapidly since the 1950s due to urbanization and population growth, reaching approximately 800 km³/year in 2000. According to the 2025 projection, this is expected to reach 1,200 km³/year. Here, the difference between withdrawal and consumption is less than in agriculture, meaning that more of the water is returned to the system in domestic use (Figure 12).

3) Industry: Water use in industry has also increased since the mid-20th century, particularly after 1975, reaching around 600 km³/year in 2000. It is projected to reach 800–900 km³/year by 2025. Because industrial water, like domestic water, has a high return rate, the difference between extraction and consumption remains limited (Figure 12).

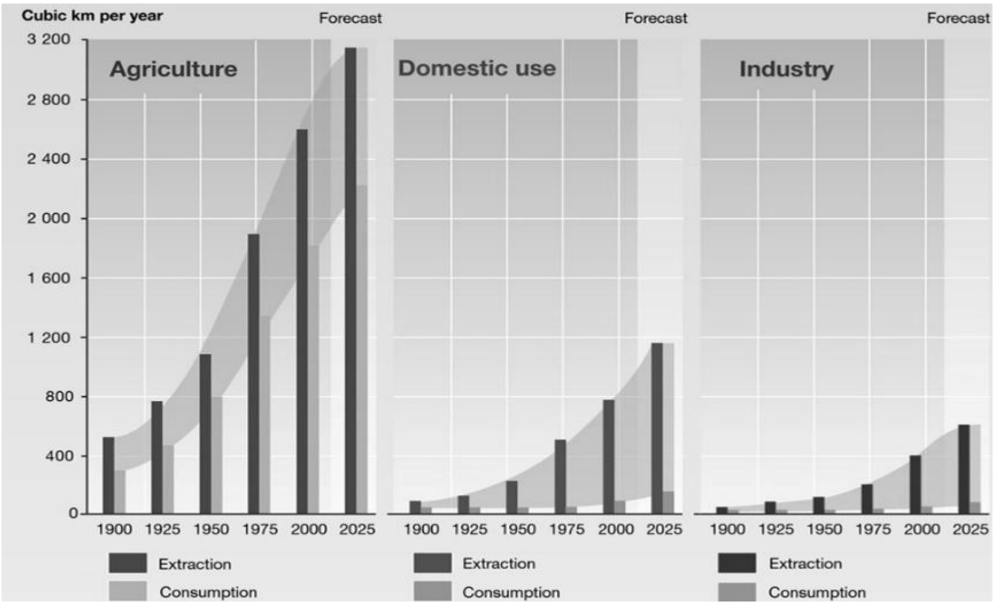

Figure 12. Trends in global water use by sector (GRID-Arendal, 2025)

When we look at the share of water used by sectors, it is assumed that there will be water scarcity in the future and there will be a decrease in the amount of water used on a sectoral basis.

3.3. Integrated Water Resources Management

The term "water resources management" (WRM) refers to all techniques and procedures required to guarantee that water systems satisfy present demands, smoothly transition into future demands into a reasonable and sustainable state, and maximize societal benefits (Akhtar et al., 2021; Quitzow et al., 2021; Koç, 2024). Policies aimed at guaranteeing a sufficient supply of water have traditionally concentrated on the development of water resources through engineering infrastructure projects. There are now no options like these in many regions of the world. This isn't because all of a country's water resources have been fully utilized; rather, water policy must acknowledge the connections between infrastructural solutions and the environment, geopolitical concerns, and socioeconomic welfare (Manhas, 2024).

3.3.1. Which Concerns Need to Be Integrated

Studies of the body of literature suggest that the writers in question have taken into account a variety of topics that must be included into this idea. This is not surprising, as previously mentioned, because there is simply no consensus within the profession regarding the definition and scope of integrated water resources management.

The integration of the following is necessary for integrated water resources management, depending on the author(s) and/or institutions (Biswas, 2008): Goals that do not have to conflict with one another (Economic efficiency, social welfare, environmental quality, and regional income redistribution);

- Water supply and demand; surface water and groundwater,
- Quantity and quality of water;
- İssues pertaining to water and land;
- Various uses of water, including hydropower generation, industrial, agricultural, domestic, and recreational;
- Rivers, aquifers, estuaries, and coastal waters;
- Water, the environment, and ecosystems;
- Macro, meso, and micro water projects and programs;
- Water-related institutions at national, regional, municipal, and local levels;
- Public and private sectors;
- Water supply and wastewater collection, treatment, and disposal;
- Urban and rural water issues;
- İrrigation and drainage;
- Water and health, as the following (Ugwu, 2025).

4. Discussion

Recognizing impending challenges enables us to better manage, plan, and model in anticipation of them. In order to adapt our techniques of analysis and solution, it is our duty as researchers to understand the relationships and functioning of complex systems and issues. The primary sources of problems in water management are the dynamics and usage of water in connection to land. Human activity on land reduces natural functioning and dynamics, especially in densely populated areas. This leads to a number of problems for water security, such as heat stress, chemical and hydromorphological stressors, flash floods, soil erosion and rapid drainage, and groundwater depletion. The interplay of these many ways in tackling water security challenges calls for integrated plans that emphasize improving each aspect of a basin approach, from source to sea.

Globally, the costs to public safety and the impact on infrastructure are increasing. Implementing mitigation strategies and developing science- and engineering-based climate change resilience protocols requires cooperation and an understanding of the risks associated with using conventional approaches for infrastructure design, construction, and operation (Koç, 2024). Furthermore, research highlights that implementing nature-based solutions and ecosystem-based adaptation can reduce climate-related risks while also offering a number of co-benefits, including enhanced water quality, flood control, and biodiversity preservation. Due to its geographic position and varied temperature, Turkey has an abundance of water resources; yet, in recent years, drought and climate change have presented serious threats to agricultural productivity and water management. As of 2023, a number of regions in Turkey face the risk of drought due to rising temperatures and decreasing precipitation. In addition to diminishing water supplies, drought has a substantial effect on agricultural practices, ecosystems, and energy generation. Particular problems in Turkey's interior include dwindling groundwater levels and disruptions to the seasonal rainfall cycle. The agricultural industry is a major contributor to the nation's economy, but drought conditions that reduce agricultural output put food security at danger. Climate change has become a reality for Turkey. The effects of climate change are emphasized by extreme weather events, high temperatures, and significant precipitation. This situation necessitates the development of more comprehensive and careful planning for the management of water resources. Modernizing irrigation systems, saving water in agriculture, protecting groundwater resources, and implementing integrated water resource management strategies are all essential steps in the fight against drought and ensuring sustainable agricultural production. It's also essential to examine Turkey's water management rules, improve residents' access to water resources, and raise awareness and understanding.

The body of research indicates that in addition to technological solutions, institutional changes, stakeholder involvement, and governance models that promote sustainability and resilience are also necessary to battle drought and climate change. One of the most important aspects of creating long-term adaptation plans is integrating scientific information with regional customs and legislative frameworks.

5. Conclusion

In conclusion, there are ecological, economic, and social facets to Turkey's drought and climate change problems. It is crucial to preserve water basins, make sure ecosystem services are provided sustainably, and put climate adaption strategies into action. All stakeholders, including legislators, local communities, and academic institutions, should take part in the co-creation of long-term solutions through the adoption of a holistic and integrated approach.

Future water security in Turkey depends on the wise and fair use of water resources, aided by enhanced irrigation technology, conservation-focused farming methods, and robust governance frameworks. The nation's capacity to adapt will also be improved by bolstering institutional capabilities, raising public awareness, and integrating climate resilience into national water policy. The resilience of Turkey's ecosystems, communities, and economy in the ensuing decades will ultimately depend on its willingness and ability to combat climate change and protect its water supplies.

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7. Compliance with Ethical Standard

a) Author Contributions

1. EK.: Conceptualization, process, software, verification, formal analysis, research, materials, authoring the first draft, composing the review, and editing, visualization, and oversigh,

2. CM.: Conceptualization, process, software, verification, formal analysis, inquiry, materials, data curation, authoring the first draft, reviewing and revising it, visualization, and oversight.

The published version of the manuscript has been read and approved by two authors.

b) Conflict of Interests

There is no conflict of interest, according to the authors.

c) Statement on the Welfare of Animals

Not relevant

d) Statement of Human Rights

There are no human subjects in this study.

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