Issues of Water and Climate Change in the Kurdistan Region and Iraq. A Review Study

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Abstract:

The Climate change, vast change in land use and land cover due to infrastructure projects, rapid population growth increases water demand and in addition to improper management of surface and groundwater the water resources in Kurdistan region and Iraq has been affected the water resources. The goal of this work is to shed light on the current state of the water situation in the Kurdistan Region and Iraq and attempt to address the fundamental causes of the issue. A nation that is currently under water stress may become one that is water scarce as a result of poor management of its water resources. Water resources in the Kurdistan Region and Iraq have significantly decreased in recent years; the country faces enormous challenges due to dwindling water supplies and sharply declining water quality. According to the research, there will be fewer frost days, more frequent heat waves, and an increase in the mean annual temperature of 2 °C by 2050. In addition to a 22% average reduction in runoff and a 9% mean annual average rainfall drop by 2050. The results demonstrate that management calls for a higher water council made up of the Prime Minister, the Ministry of Water Resources, and cooperation with the Kurdistan Region authorities because solutions to utilize water resources begin there and spread to southern Iraq, the regions that pay the highest taxes due to mishandling of the water file. Concerns over water also need to be addressed globally and regionally.

Keywords: Climate change, environment, fresh water, global warming, precipitation, water quality.

1. INTRODUCTION

In general, the world is struggling with a confluence of crises- climate change, and stopping progress towards the sustainable development goals (ESCAP, 2023). Iraq's water resources have drastically declined in recent years, and the country is facing severe challenges as a result of

diminishing water supplies and rapidly falling water quality (Al-Ansari et al., 2023) The international community supports Iraq's and Kurdistan Region-Iraq (KRI) efforts regarding the water crisis. In addition, water issues are well covered in most literature conducted by United Nations organizations, international and local researchers, and for different periods of time. KRI is mostly mountainous and rich in ecological, social, and economic diversity. It has enormous potential for sustainable development but is also hindered by issues of accessibility, marginalization, and fragility. The presence of a wide variety of rivers, streams, and springs with varying lengths, widths, discharge and flow characteristics, catchment types, and water quality characterizes the hydrology of the (KRI) (Maulood and Hinton, 1978). The annual precipitation ranges from 300 mm to 1000 mm in the north and from 100 mm to 200 mm in the south and west (UNEP, 2007). The Tigris and Euphrates flow and their tributaries are vital to the central alluvial plain. The north and east of Iraq and its surrounding nations are home to the majority of catchments and groundwater recharge zones. Groundwater naturally becomes salinized as a result of the high rates of evaporation in dry regions relative to precipitation and natural recharge (UNEP, 2007 as referenced in Price, 2018). Iraq's environment is under stress due to a number of interrelated factors, including the country's expanding population, the unrest that has been there since 2003, poor land use planning, and urban expansion (World Bank, 2017). Iraq's declining biodiversity, air pollution and worsening air quality, limited and contaminated water supplies, and contaminated marine waters are all examples of these detrimental consequences on the country's environment (World Bank, 2017). The objective of the current work is to shed light on the present state of the water situation in KRI and Iraq and attempt to report the essential causes of the subject. To date, this kind of study has not been conducted.

2. CLIMITE CHANGE AND GLOBAL WARMING

2.1 Geographical Location of Iraq

Iraq is one of the Middle East and North African countries (MENA region), which is reported to be the most water-scarce region in the world. The country is currently facing a serious water shortage problem (Al-Ansari, 2013; Adamo et al., 2014; Abbas et al., 2016). Due to its geographic location, Iraq experiences extreme weather conditions. The majority of the country is covered in desert and semi-desert climates, which are marked by high temperatures, clear skies, and concentrated solar radiation. This increases evaporation, which causes a serious water shortage (Elaiwi et al., 2020).

2.2 Water Scarcity and Population Growth

The UN Environment Program (UNEP) has long warned that water availability in Iraq will decrease by around 20% by 2025, threatening the long-term stability of agriculture and industry sectors (UNEP, 2007). According to Iraq's Ministry of Planning, the country's population

reached 41 million in the end of 2021, with nearly 70% living in urban areas and 30% in rural areas. In 2020, Iraq's population grew by 2.5%, which is considerably high by world standards. Due to the lack of investment in rehabilitation and human resources, Iraq is not prepared for the present rate of population growth. Iraq's environment has been subject to a number of converging pressures stemming from population growth, the impact of three wars and their aftermath, poor land use planning, urban sprawl, and encroachment on fragile ecosystems (World Bank, 2017). Iraq experiences very little precipitation and much of the nation is desert or semi-arid. From 1951 to 2000, there were a variety of variations in the amount of rainfall each year, including both increases in the northeast of Iraq and declines in the southeast and west of the country. Moreover, longer heat waves and increased evapotranspiration have negatively affected water availability and storage (USAID, 2017; Price, 2018; Lootsma, 2023).

2.3 Draught in KRI and Iraq

Year 2023 is confirmed as the warmest calendar year in global temperature data records dating back to 1850. The heat dome affects Iraq for the first time this year and creates a strong heat wave in the south (C3S, 2024), Figure 1.

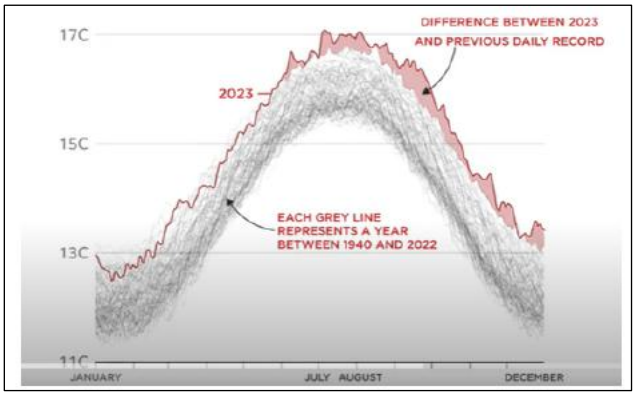


Figure 1: Daily Global Average Air Temperature 1940-2023

Increase in mean annual temperature of 2°C and a decrease in mean annual rainfall of 9% Predicted for 2050, with a decrease of 17% for the winter months (December, January, and February) (USAID, 2017). Iraq witnessed two notable drought spells, from 1998 to 1999 and from 2007 to 2008, as well as severe drought exacerbations between 1998 and 2009 (Hameed et al., 2018). In the Notre Dame Global Adaptation Index, Iraq ranks 126 out of 181 countries overall and is one of the world's five most environmentally vulnerable and weak countries (Grant et al., 2023). Significant reduction in green area occurred as well. The Kurdistan Regional Government's Minister of Agriculture reports that 12.44% of the region is green. Thirty percent of the artificial forest and fifty percent of the natural forest have disappeared in recent years. The Marshes region had a notable decrease in water levels, culminating in an unparalleled drought in the region's history (Isra et al., 2020). This extreme circumstance compelled the populace to

relocate from the marshes to the cities, and the extent of vegetation, which included papyrus and reeds, declined when the marshes dried up in 1993. It peaked in 1973 as a result of a significant reemergence of water in the marshes (Isra et al., 2020), Figure 2.

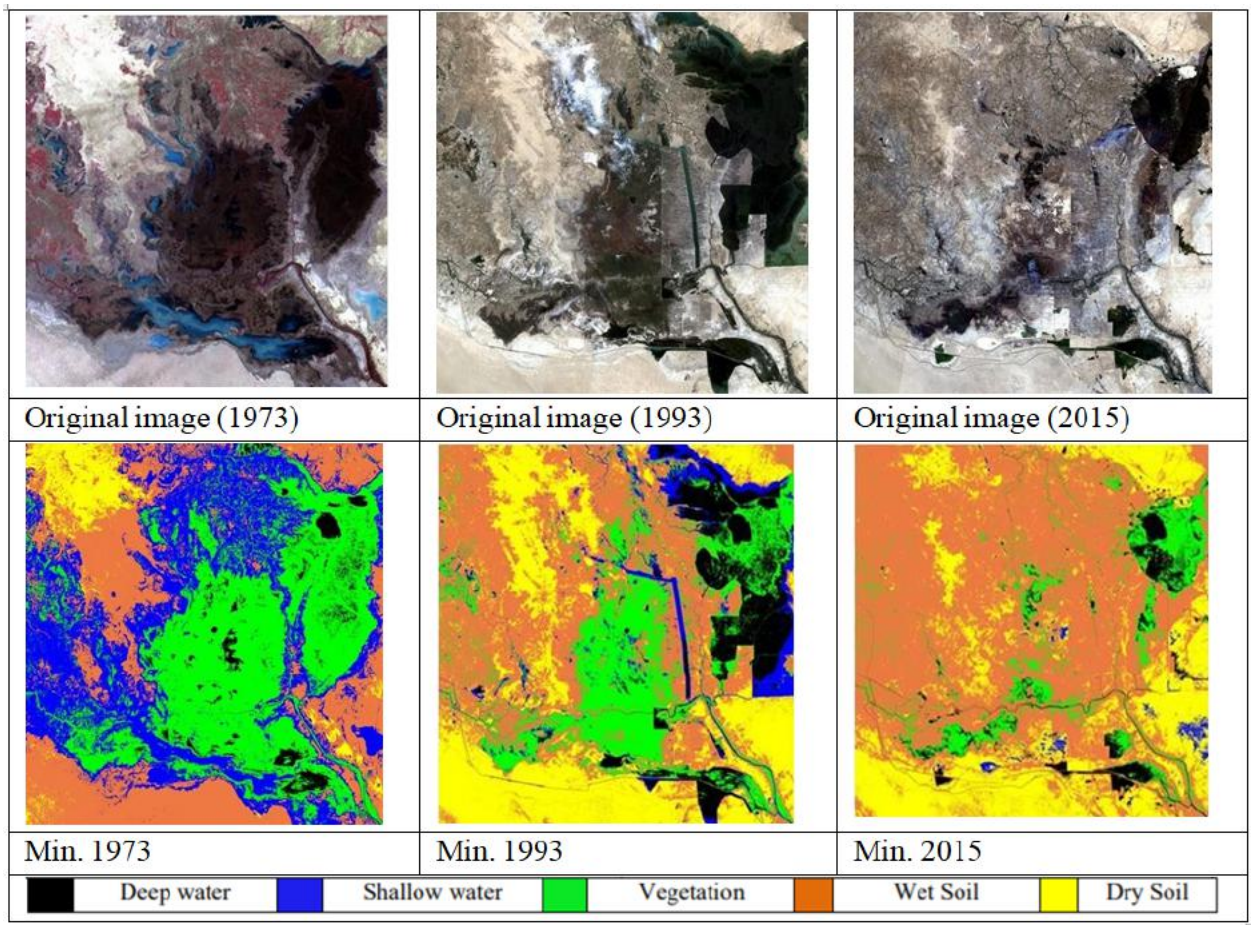


Figure 2: Marshes situation throughout 1973 to 2015

The results of a study that examined the potential for mapping hydrological drought vulnerability in the Mandawa watershed, which has a land surface area of 3542.46 km^2 in the KRI, using remote sensing data and geospatial analysis showed that the years 2007 and 2019 were the worst for drought in Iraq. According to the findings, the research area's vulnerability to extreme and severe droughts is, respectively, 5.2% and 13.8% and, more than 35% of the watershed is not particularly susceptible to droughts (Ahmed and Suleimany, 2023).

2.4 Environment

Iraq is among the 10 largest oil-producing countries in the world. In 2019, atmospheric concentrations of carbon dioxide (CO2) and other greenhouse gases reached previously unheard-of heights (WMO, 2020). Iraq is using non-renewable fuels. For example, there are about 5,000 general electric generators and more than 3,000 private electric generators in the KRI. In

addition, 2.37 million vehicles that consume fuel daily. However, many researchers found that "in the past seven months of the current year, the air quality index in Erbil has reached yellow and red levels in most cases". In 2020, the number of cancer cases in Sulaymaniyah reached 6,293 cases, and it rose to 7,904 cases in 2021. In 2022, the number of cancer cases reached 9,610, and in 2023, the number reached 90,911 cases. This increase indicates that the area exposed to many toxic and dangerous gases every day. Research findings considered poor-quality fuel to be a major cause of environmental pollution and believed that "there is no typical refinery in the Iraq and KRI that can separate all components of gasoline and diesel to reduce risks to the environment and public health. Heavy rains led to floods and torrents in the northern and eastern regions of Iraq, damaging a large number of shops, roads, households, and properties. Flooding pollutes groundwater and surface water. Floods speed up urban runoff, contaminating freshwater resources with toxic pollutants (Aziz et al., 2023), Figures 3.

Erbil City 2021 Erbil City 2021

Duhok City 2024 Zakho City 2024

Figure 3: Erbil city 2021 flash floods, Duhok city floods claim two lives with damage over 30 homes and damage over 400 houses in Zakho province 2024.

3. DAMING THE EUPHRATES AND TIGER RVERES

3.1 The Principal Water Resources in Iraq

It's the Tigris and Euphrates rivers, and Mesopotamia. The two dominant rivers in Iraq are the Tigris and the Euphrates. Both of them are Transboundary Rivers originating in Turkey and provide more than 80% of Iraq's water demands for various purposes (Abd-El-Mooty et al., 2016; Daoudy et al., 2024). Ratio of 40% of the Euphrates and 58% of the Tigris run inside Iraq. Since the two rivers meet at the Shat al Arab basin in southern Iraq, Turkey views the two rivers as belonging to a single basin. Since Turkey would have more control over how much water it releases to its neighbors downstream, it would be more advantageous for them to view themselves as one basin (Jakob, 2022). One of the Tigris's major undammed tributaries, the Greater Zab River traverses both Iraq and Turkey. The Greater Zab River's rapid flow through valleys covered in mountains makes it particularly well-suited for hydropower. The rivers Fishkhaboor, Nahr at Tib, Dewarege, and Shehabi; the Lesser Zab (originating in Iran) while the Diyala (originating in Iran); and the Adhaim river, which is wholly located in Iraq (Sharef et al., 2021; Al-Mooji, 2022). With a catchment area of over 67,000 km^2, the Karun River is the most significant downstream tributary and has a major influence on salinity intrusion along the Shatt al-Arab. (MOWRI, 2014). There are three primary forms of groundwater recharge: precipitation and surface water infiltration, which occur naturally; artificial recharge via agricultural irrigation. The northern, rainier regions of Iraq are where recharging happens most frequently, with annual recharge rates ranging from 100 to 300 mm (Price, 2018; Todd, 2023), Figure 4.

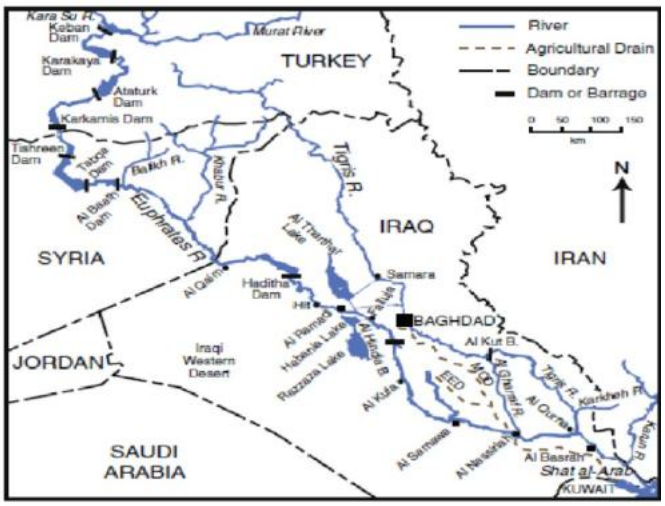
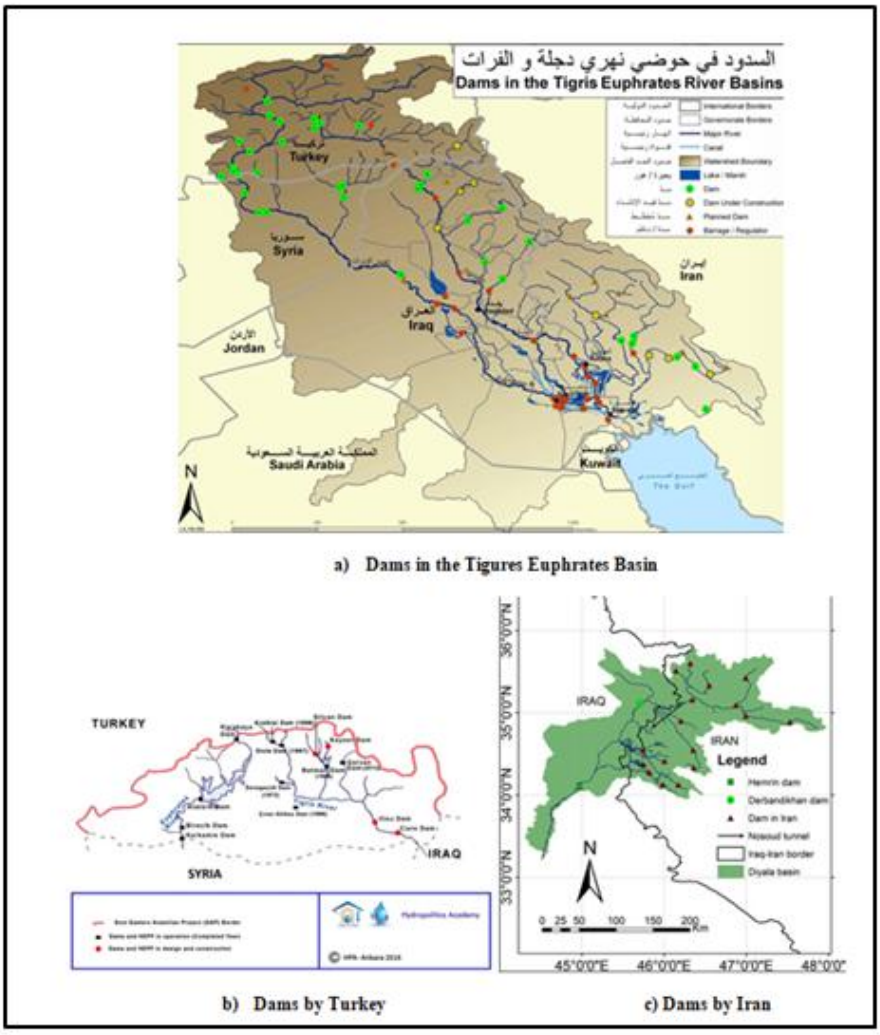


Figure 4: Rivers in KRI and Iraq

3.2 Constructed Dams by Turkey and Iran

If appropriately utilized, the two rivers could supply adequate amounts of water. The water flow in Iraq's Tigris and Euphrates rivers has decreased by 29% and 73%, respectively, as a result of dam construction in nearby nations (UN Iraq, 2021). A nation that was severely affected by drought in 2007–2009 and 2019 may experience further drought as a result of the Ilisu Dam. Other notable implications include water contamination, deterioration of the water quality, and loss of agricultural area (Asaad, 2024). Iraq will lose up to 47% of its annual water income and about 40% of its agricultural lands, which will in turn decrease its agricultural output, causing unemployment and the subsequent displacement of Iraqi farmers (Al-Salihi et al., 2020). In Northern Iraq we have seen an example of this with the Alwand River (another Tigris tributary) drying due to upstream diversion and damming in Iran, having devastating consequences for farmers (Price, 2018). Iran has dammed the Karun River, a tributary of the Shatt al-Arab river in southern Iraq, as well as rivers flowing into KRI, Figure 5 (Olson and Chernyanskii, 2024).



a) Dams in the Tigures Euphrates Basin

b) Dams by Turkey

c) Dams by Iran

Figure 5: a)Dams in the Tigures Euphrates Basin ; b)Dams byTurkey ; c) Dams by Iran

3.3 Accesses to Fresh Water

KRI and Iraq's water supplies have been deteriorating for several decades, especially in the agriculture and domestic sectors. Iraq's water distribution networks are extremely inefficient; they only utilize roughly 32% of their overall operational capacity. The country's water demand is approximately 11 x 10^6 m3/day, yet only half of this quantity is being supplied (Al-Ansari, 2014; Elaiwi et al., 2020). Table 1 and Figure 6 illustrate the food-insecure people by region, 2020 and 2050 projections (WFP, 2021).

Table1 The food-insecure people by region, 2020 and 2050 projections (WFP, 2021)

Present	**Future**
Unmet demands! ▪ **2.0** billion people have no access to safely managed drinking water (2020) ▪ **0.8** billion people have no access to electricity (2021) ▪ **2.4** billion people are food insecure (2020)	**Increasing demands!** ▪ Due to population growth, economic development and changing consumption patterns. ▪ The uncertainties of global change exacerbate the difficulty in achieving these goals

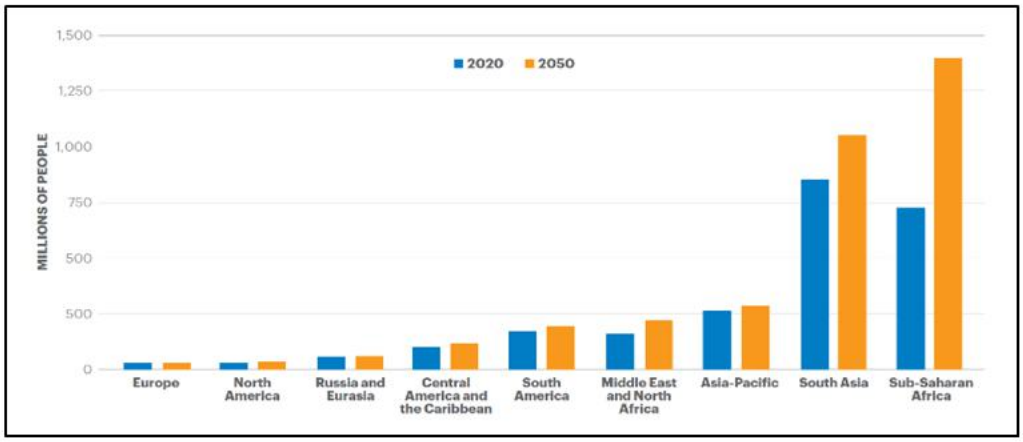


Figure 6: Food-insecure people by region, 2020 and 2050 projections Source: IEP, 2021

Nearly 3 out of 5 children in Iraq have no access to safely managed water services, and less than half of all schools in the country have access to basic water, risking children's health, nutrition, cognitive development, and future livelihoods (UNICEF, 2021; Elaiwi et al., 2020). In Iraq, just 8% of the population has access to clean water, and only 14 out of 252 cities have sanitation facilities, meaning that most people do not have access to basic sanitation services (UNICEF, 2021). For instance, the Thi-Qar governorate's average daily potable water per person was 284

L/capita/day, less than the national average of 340 L/capita/day (Ethaib et al., 2022). Opinion Research Business spoke with 400 Baghdad residents over the phone. As seen in Figure 7, most participants61 percenthave little to no access to clean drinking water, according to survey results (ORB, 2023).

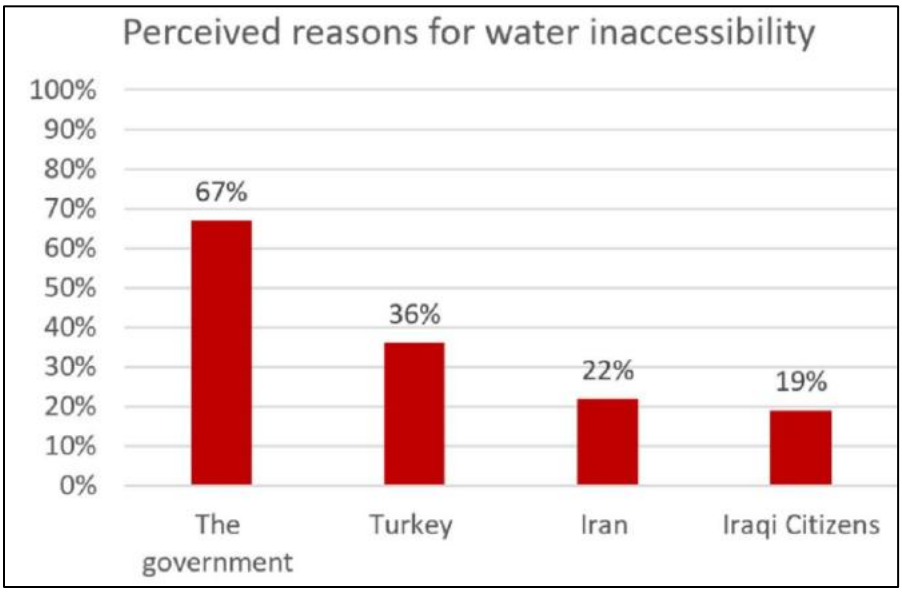


Figure 7: (ORB) International in 2023

The most of water in Iraq is used for agriculture. In 2017, 87.8% was used for agriculture, 2.5% for industrial uses, and 2.7% for municipal water supply (FAO, 2022).

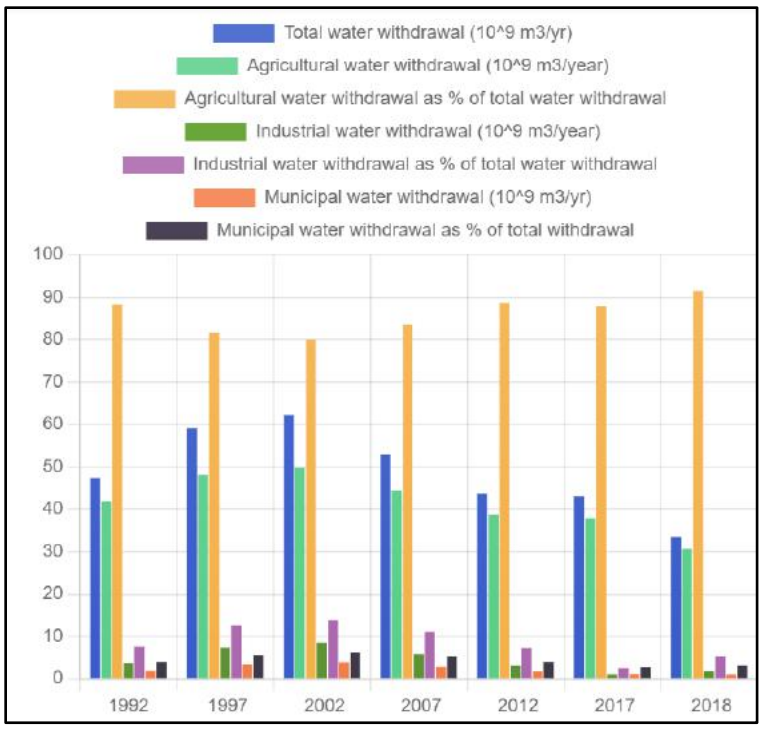


Figure 8: Water withdrawal in Iraq by sector

One of the most significant economic sectors in Iraq is the agricultural industry, which ranks second in terms of GDP contribution behind the crude oil industry. Nevertheless, from 26.93% in 1991 to 10.86% in 2004, 7.23% in 2010, and 4.77% in 2020, its share of the GDP fell (Drebee et al., 2022). Actually, according to (Khalaf, 2023), Iraq's water resources are drying up at a pace of 8–12 x10^9 m3/year, which is equal to the cubic mass of around 120 billion shipping containers.). Tharthar Lake (an artificial lake created in 1956, situated 100 kilometers northwest of Baghdad between the Tigris and the Euphrates rivers) alone is presently responsible for more than 50% of the evaporative losses from Iraq's reservoirs. The worst of the crisis, however, is in the south of Iraq. Southern Iraq lacks these benefits, while the country's north has access to more water and of higher quality due to its abundance of water sources and proximity to the sources of the two rivers and their tributaries (Al-Ansari et al, 2023)

3.4 Water Purity and Contamination

Iraq is currently facing two distinct types of water quality issues. The first is salinity, and the second is the amount of contaminants in the water brought on by agricultural, industrial, and municipal operations (Christen, 2013; Singh, 2019). Water pollution is more significant in the south because it is the meeting place of the two rivers, the Tiger and Euphrates. As more families and individuals are relocated to overcrowded cities with few resources and employment possibilities, these situations are predicted to get worse over time (Fanak Water, 2022), Figure 9.

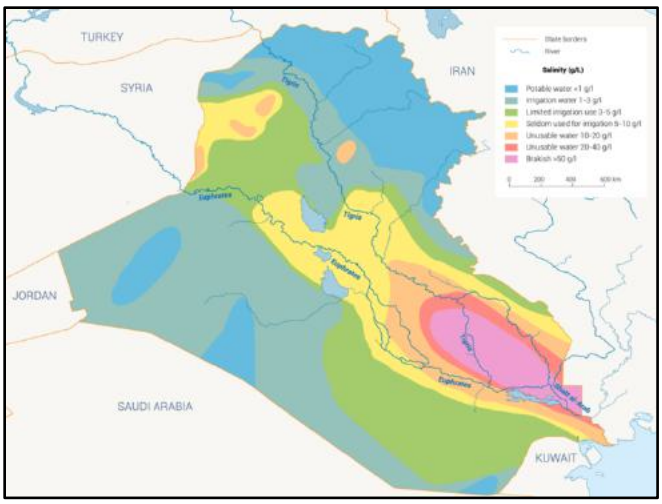


Figure 9: Iraq's groundwater salinity

Iraq's rising temperatures, land loss, evaporation, high river sediment, disregard for sanitary systems, and direct discharge of these materials into rivers resulted in pollution and a decline in river quality (Ethaib et al., 2022). As the Arab Gulf's sea levels rise, salt water from the Shatt al-Arab basin is pushing upstream along the river and has intruded as far north as 189 kilometers, making the farming land in southern Iraq saltier, ruining drinking water supplies and forcing many people into the cities. (Alwash, 2023; Al-Salihi et al., 2024). As of March 15, 2023, 12,212 families were still displaced in 10 governorates in the central and southern regions of Iraq, according to a research by the International Organization for Migration. If nothing is done, these numbers are only likely to rise over time. As a result, 39% of Iraq's land area is affected by desertification, and 54% of the country faces the grave threat of soil degradation. (Alfardan, 2021).

3.5 Why Managing Water Resources?

In addition to meeting the population's growing food needs and accelerating urbanization, water resource management promotes public health, the prevention of waterborne illnesses, and the security of safe and clean water. Additional research on water resources may contribute to better water conservation, a decrease in greenhouse gas emissions, and a mitigating influence on climate change.

4. PROPOSED SOLUTIONS AND RECOMMENDATIONS

The following solutions and recommendations are outlined:

- Adopt an integrated approach to water management that promotes cooperation and coordination among pertinent authorities by taking into account the interdependence of water systems, stakeholders, and sectors.
- Building safe water reuse systems and wastewater treatment plants for non-potable uses such as irrigation, industrial activities, washing, cooling, and urban green areas.
- Using artificial groundwater recharge to raise the quality of the water and thus reduce the phenomena of desertification.
- Empower a Woman with water and She Can Change Her City or Her Story. The water crisis affects women most, and they have the power to solve it for their families as they are prime managers of water at the household level.
- Oil is essential to the Iraqi economy and should store carbon and methane. Instead of letting the profitable output from gas flaring go untapped, it must be used.
- Revive Marches and increasing GREEN canopy which plays a vital role in enhancing urban environments and contributing to the well-being of cities and their residents.
- Using the "Return to the Nature" principle or "sponge city policies," which are a collection of natural solutions that employ landscapes to collect, hold, and purify water. The idea was inspired by long-standing advice on how to adapt to climate change.Implementing smart irrigation technology as "dripping" technique and advice farmers in vulnerable southern governorates to move from rice to other crops (such as vegetables).
- Remote Sensing and GIS technology should be applied foe water resources managment

5. CONCLUSIONS

- Water security is the capacity of a community to limit the risks of water's destructive effects to an acceptable level in a way that protects the environment and guarantees the long-term sustainability of water resources. All should have sustainable and safe access to fresh water for a variety of uses, including drinking, irrigation, and industry.

- Turkey and Iran countries do not agree to share losses in water sector due to climate change and sharing the Iraqi government in overcoming the devastating impact of water shortage
- Despite the presence of prior agreements in this regard, such as the 1946 deal with Turkey and the 1975 agreement with Iran, there is no clear agreement on water between Iran and Turkey.
- Insufficient water infrastructure and poor attention to the water resources sector as a whole. The decision-makers in Iraq did not give priority to the water crisis because of

their preoccupation with politics and the division of Iraqi society, and they do not carry out long-term plans that work.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest regarding publishing the current work

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