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Effect of Climate Changes on Water Resources in Iraq: a Review Study

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Abstract. Iraq has a lack of water resources due to climate change. Historical data analysis found that the region is undergoing climate change to a greater extent than is commonly reported elsewhere. The link between climate change and its impact on a region's water supplies has received little attention in written literature. Climate change is one of the most major factors posing a hazard to all humans on the globe. Climate change may occur because of both natural internal processes and external pressures, as well as detectable anthropogenic alterations. Climate change is responsible for the observed significant temperature fluctuations, greenhouse gas emissions, and sea-level shifts observed from gathered data, such as ice cores, during the previous centuries and even decades. As greenhouse gas emissions grow, major sectors of the global economy, such as agriculture and manufacturing, will suffer considerably. Human welfare and health services would suffer as a result, and progress in general will be inhibited. Large portions of the Earth will become unlivable due to a variety of factors such as ocean inundation, temperature decreases, and so on. However, other experts feel that the rise in the proportion of greenhouse gases emitted has reduced or postponed the chance of a new ice age.

INTRODUCTION

Climate change has become a major topic for the media and protracted debates among politicians in several nations. The emphasis of this transformation is global warming, which is now seen everywhere. Many scientific investigations and studies have been undertaken to date on the elements that contribute to this warming and its role in catastrophes and profound environmental changes. Climate change may have a large influence on water supplies and the hydrological cycle, resulting rapid melting of the snowpacks at the North and South Poles, accompanying sea level rise, and changes in precipitation patterns worldwide [1]. Climate, seas, and land have been warmed by humans. The atmosphere, ocean, cryosphere, and biosphere have changed rapidly [2]. Climate change affects the biological and physical components of ecosystems, such as air, water, soil, and biodiversity, and has both direct and indirect effects on numerous sectors of the economy and society [3]. The consequences of climate change on global water supplies and demand are anticipated to be extensive. Increasing sea levels, for instance, might jeopardize the lives and livelihoods of millions of coastal residents. In certain regions, water shortages are anticipated, while in others, demand is expected to increase. Climate change would undoubtedly increase the frequency of floods and droughts, hence increasing the likelihood of poverty and famine. A high spatial and temporal resolution is essential for the long-term strategic planning of a country's water resources considering the effects of climate change [4]. Several parts of the globe have already seen an increase in the number of severe high- and low-flow events, making societal infrastructure more vulnerable to climate change [5]. Furthermore, severe occurrences that are caused by flooding are becoming more frequent these days, and they are expected to continue at the same rate or perhaps accelerate in the future [6]. Irrigation, water resources, the environment, and Iraq's agricultural sector are all negatively affected by climate change, which is unquestionably a major problem for Iraq [7]. Iraq is a riparian country in the Tigris-Euphrates River basins in the Middle East area. Due to rising demand and climate change, the area is presently experiencing water shortages [8].

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EFFECTS OF CLIMATE CHANGE ON HYDROLOGICAL CYCLE

As part of the planet's hydrologic cycle, often known as the water cycle, humans, animals, and plants are regulated. Other cycles, such as those involving carbon, nitrogen, and so on, are built on top of this one. Since the water cycle is critical to the long-term sustainability of biological populations and ecosystems, it should be stable. Empirical data suggests that climate change is endangering the hydrologic cycle's stability.

Large rivers provided easy access to usable water, which led to human civilizations forming along their shores. As a consequence, most major cities have rivers running through them. Various ancient civilizations benefited greatly from the engineering of water resource systems [9][10]. Population growth has been assisted by advances in hydraulic engineering technology throughout the preceding century. There has been a rise in demand for land, water, fossil fuel energy and natural resources as a result of growing population growth. As a consequence of these actions, the natural environment and the Earth's climate system have been negatively affected [11]. They have also had an impact on the water cycle, as climate change has resulted in substantial hydrologic shifts [12].

Water resources and the hydrologic cycle are directly affected by climate change (see Fig. 1). Climate change's impact on the hydrologic cycle will necessitate a shift in water resources in terms of both location and timing.. Another element that might be affected is the amount of water that evaporates from the soil and is runoff. Human civilization and the biosphere will be profoundly affected by the redistribution and changes in water supply in space. Both local climate and climate change will be worsened by changes in water resources systems simultaneously [13].

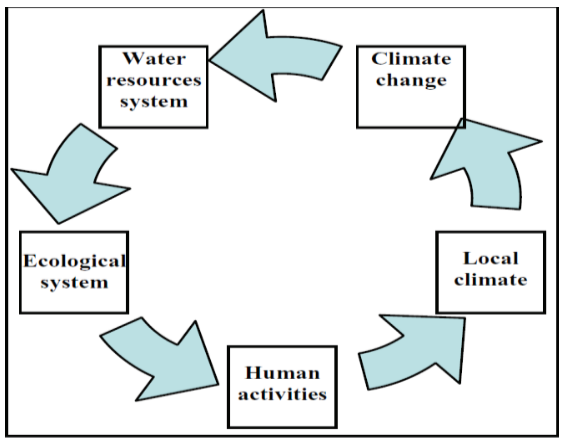

FIGURE 1. Cycle diagram of climate change affects.

Below are a few of the most severe issues that climate change has caused for the water:

Snow and ice melting: the ice sheet shrank as a result of the hot weather. The Arctic ice cover declined by 10% between 1975 and 1995, according to studies and research [14]. For hundreds to millennia, past and future greenhouse gas emissions will have an irreversible effect on the oceans, ice sheets, and the global sea level [2]. Furthermore, recent years have seen an earlier start to snow melting than in prior century' 1940s. Many environmental concerns occur from this melting, including sea-level rise, higher precipitation in certain regions, and the related spatial shifts in storm patterns [15].

An increase in the level of the oceans: the rate at which the water level is rising is unprecedented. As it becomes hotter, the volume of water expands. This can only result in a rise in sea level compared to land in the case of the ocean. The thermal expansion of ocean water accounts for two-thirds of twentieth-century sea-level rise, while melting glaciers and ice caps give fresh water to the sea [16][17]. Because of the ongoing warming of the deep ocean and the melting of ice sheets, the global average sea level is projected to keep rising over the next few hundred to a few millennia and to remain high for the next few thousand years [2].

Drought: is a recurrent severe climate phenomenon that occurs across land and is marked by below-normal precipitation and typically heated temperatures lasting months to years [18–20]. A warmer climate may exacerbate extreme wet and dry weather, climatic events, and seasons, perhaps leading to floods or drought [2].

EFFECT OF CLIMATE CHANGE ON THE ENVIRONMENT

UNESCO's International Hydrological Programme (IHP-IV) project H-2.1 is grappling with a brand-new problem: global climate (and climatic variability) and hydrological regimes impacting water balance components. Climate variability and change will have an effect on the hydrological cycle, impacting water distribution and availability for domestic consumption, agricultural output, industrial activities, and hydropower generation [21].

The effects of climate change extend from science to technology to the environment to culture to the economy to politics. As a result, substantial and coordinated actions are necessary to mitigate and adapt to the effects of climate change. Several repercussions have happened as a result of earth system chain reactions. Consequently, the socioeconomic factor should be brought into the climate change debate [11].

The effects of climate change on biodiversity and water supply are detrimental. Without additional efforts, it would become the most major driver of future biodiversity loss [22]. Precipitation is the major operator of the biotic environment, and it has the biggest influence on agricultural production of any climatic parameter [23]. Global climate change affects the long-term rainfall pattern, which affects water supply and raises the risk of severe drought and flooding [24].

Researchers want to study the effect that climate change has on the hydrology of the Andasa watershed beginning in 2013 and continuing until 2099 [25]. Before attempting to investigate the impact of climate change on water balance, the soil and water assessment tool, often known as SWAT, was subjected to calibration and validation procedures. According to the results, climate change may cause moisture-constrained scenarios in the watershed, which may have an effect on agricultural activities in the watershed. Appropriate agricultural water management activities should be done to minimize and adapt to the possibly negative impacts of climate change by conserving soil moisture and minimizing evapotranspiration. Understanding how temperature and precipitation influence water resources in the context of climate change is crucial for better anticipating their future dynamics, especially in vulnerable locations such as mountainous woodland regions. A study examined variations in temperature, precipitation, and flow at annual and seasonal scales using a long-term (1988–2018) daily collection of hydro-climatic data for the Strengbach watershed (France; OHGE) [26]. The findings revealed that the local climate altered in accordance with worldwide observations of increases in temperature (+0.04 °C.yr1) and total precipitation (+6.9 mm.yr1). Climate change varied by season, with temperatures rising in autumn (+0.07 °C.yr1), summer (+0.05 °C.yr1), and spring (+0.05 °C.yr1), but falling in winter (–0.03 °C.yr1). Total precipitation rose (+4.2 mm.yr1) in summer and (+2.1 mm.yr1) in winter due to more days with very heavy and heavy precipitation, respectively. The Strengbach catchment's long-term hydrological behavior has also changed, with a decline in the discharge: precipitation ratio and rapid flow volume, primarily during the winter.

CLIMATE CHANGE'S IMPACT ON WATER QUALITY

Stream temperature is a key feature of lotic systems, impacting dissolved oxygen levels, nutrient cycling, chemical reaction rates, productivity, and mortality in aquatic ecosystems [27]. Climate influences stream temperature, making it particularly sensitive to climate change [28]. Heat drives it forward. Source temperatures and heat exchange with the surrounding environment and streambed power it (i.e., groundwater, snowmelt, overland flow, and precipitation). According to long-term data analysis [29][30], and modeling studies, stream temperatures have already risen in recent decades as air temperatures have [31–33], possibly decreasing availability for Coldwater species.

Climate change has a physical influence on the volume and quality of water. Summer stratification in drinking water reservoirs has grown and surface water temperatures have risen as a result. The bio-geochemical processes and, as a result, the water quality, are greatly influenced by stratification and temperature in the production of drinking water [34]. Water temperature, dissolved oxygen, and nutrients, as well as the long-term implications of global warming on aquatic ecosystems, have all been examined in this research. Water quality at Shimajigawa Reservoir in western Japan is modeled using a watershed runoff model established via research and a reservoir water quality model informed by a GCM A2 (general circulation model) scenario. To evaluate the climate change sensitivity and its long-term effects on water quality and aquatic ecosystems [35]. contrasting the lake model simulation results for 1991–2001 with those for 2091–2100. In comparison to the 1990s, the 10-year average surface water temperature is anticipated to climb by 3.4 degrees Celsius in the 2090s. Hypolimnion water temperatures are expected to increase by 2.8 degrees Celsius while surface water temperatures are predicted to climb by 3.8 degrees Celsius. Consequently, it is projected that increasing temperatures will extend the thermal stratification period and deepen the thermocline. Hypolimnion phosphorus concentrations may rise due to an increase in oxygen requirements for aerobic decomposition and an increase in phosphorus transport from sediments. According to long-term estimates using a model of water quality, global warming has been shown to result in more trophic lake conditions, thereby enhancing algae growth and modifying aquatic ecosystems.

Climate change will alter the quality of irrigation water. It is generated by CO_2 emissions, CH_4 emissions, industrialization, growing population, and human activities that alter water quality via the use of heavy metals, pesticides, organic contaminants, and sedimentation.. Rainfall, temperature, floods, and droughts impact irrigation water quality. Rainfall, temperature, floods, and drought affect micronutrients, pathogens, pH, and dissolved oxygen in water. Drought, floods, and increasing temperatures will affect water quality. Rainfall affects water quality and availability. Flooding pollutes groundwater and surface water. Floods speed up urban runoff, contaminating freshwater resources with toxic pollutants. Toxic industrial waste is deposited in waterways, contaminating irrigation water. Heavy elements like lead and cadmium pollute irrigation water, affecting agriculture [36]. Research done in the Colombian Andean province of Caldas explored people's perspectives on the influence of climate change, notably on water supply [37]. According to the findings, respondents believe that climate change is seriously threatening the supply and quality of water. They proposed promoting the protection of hydrographic basins and tightening controls on discharging liquids into surface water sources as adaptive efforts.

CLIMATE CHANGE AND WATER IN IRAQ

Iraq is one of the Middle Eastern nations bordering the Tigris and Euphrates rivers. Due to increased demand and climate change, the area is now experiencing water shortages [38]. Snowmelt and rainfall in southeast Turkey, northeast Syria, northwestern Iran, and northeast and east Iraq feed the Euphrates and Tigris rivers. Winter crops won't be damaged by March and May River flows, but summer crops will. Devastating floods are not unheard of since river flow fluctuates so much from year to year. Irrigation and agriculture have become troublesome due to years of low flow. This regime must be understood as a whole, from Turkey at the headwaters of both rivers to Syria in the northwest, Saudi Arabia in the southwest, and Iran in the northeast and east. Some Tigris River tributaries originate here, while the Karkha and Karun Rivers flow into and pollute Shatt Al-Arab. Less than 150 millimeters of annual precipitation and considerable evaporation classify the country as dry or semi-arid. [39].

One of the most pressing issues Iraq faces is the depletion of water supplies due to climate change, which might have a detrimental effect on both the environment and the economy, especially agriculture. There are water shortages and pollution in the Greater Zab catchment area, Iraq's biggest tributary of the Tigris River. Recent research has found that the basin's blue and green waters have been exhibiting greater unpredictability, perhaps leading to more severe droughts and floods as a result of climate change [40]. Drought is one of the most expensive natural catastrophes in the world, causing damage to human activities, the economy, agriculture, and the environment. Using mean monthly stream-flow data from three gauging stations along the Greater Zab, Lesser Zab, and Khazir Rivers in northeastern Iraq, a stream-flow drought index (SDI) was calculated to evaluate the hydrological dryness [41]. Statistics compiled by the SDI show that the Greater Zab River Basin and the Lesser Zab River Basin both endured a severe drought over the course of three and six months, respectively, owing to a lack of rainfall throughout the summer. 185 billion m3 of Tigris River water flowed downstream of Mosul Dam from 1990 to 1999. (2010-2020). Accordingly, the Tigris River suffering drought owing to the climatic consequences. Average monthly water flow measurements from 15 stream flow gaging sites in Iraq's river basins were combined with population growth rate data in selected areas to examine the current state and future challenges of water supply and demand [8]. Iraq obtains 70.92 km3 of water annually from the Tigris and Euphrates rivers, which contain 45.4 and 25.52 km3 of water, respectively. Turkey contributes 18.04 km3 to the Tigris, whereas Iraqi tributaries provide 27.36 km3. The Euphrates River's water comes from outside Iraq. The Tigris and Euphrates rivers lose 0.1335 km3 of water annually. The two rivers' annual inflow rates have dropped 0.294% and 0.9604%, respectively.

A study was undertaken to evaluate the most current climate model precipitation and temperature projections for the scenario of very high emissions, SSP5-8.5, in order to determine the likely future changes in this area [43]. A baseline period (1981–2010) is compared to the middle (2040–2069) and end of the twenty-first century (2070–2099). The findings of the worst-case scenario identify the Tigris-Euphrates headwaters as a potential hotspot for climate change's compounding effects in the Middle East. These effects are the consequence of high temperatures, little precipitation, and increasing interannual variability in precipitation.

Researchers in Iraq used a GIS estimate, environmental data, climate change impacts, and changes in wetland areas detected over the past three decades (1991–2021) [44] to quantify Iraq's Thi-Qar governorate's water deficit. According to the data, the annual amount of accessible water per person in Iraq is less than the water scarcity threshold (1700 m3/cap/year). The average daily potable water per person in the Thi-Qar governorate was lower than the national average (340 L/cap/day) at 284 L/cap/day.

From 1998 to 2018, six percent of the months failed to meet water needs. High levels of pollutants, such as biological pollution, were discovered in 55 percent of the total number of samples taken each year, according to water quality tests. The largest marsh size was 1548.21 km2 in 1991 and the smallest was 65.45 km2 in 1999, as measured by Landsat imagery. Additionally, the influence of projected global warming and climate change on natural groundwater recharge in an unconfined aquifer (Umm Er Radhuma) in Iraq's Western Desert was studied using the modeling program WetSpass [45]. Under the RCP4.5 (Representative Concentration Pathway 4.5) and RCP8.5 emission scenarios, precipitation would decrease by 9.2% and 14.1%, respectively, according to calibrated future modeling scenarios. RCP4.5 produces an increase of 0.96 °C, whereas RCP8.5 causes an increase of 2.05 °C. Under the RCP4.5 and RCP8.5

emission scenarios, annual groundwater recharge is projected to decrease by 13.6% and 21.2%, respectively, by the end of the century.

SUMMARY AND CONCLUSION

In the future century, climate change will present enormous, interlinked concerns of unprecedented extent and scope. Temperatures in the water are expected to rise and extreme weather events, such as floods and droughts, are expected to worsen water pollution. Furthermore, water use rises as temperatures rise. Iraq due to climate change is experiencing water scarcity owing to a variety of issues. Some of these problems, such as global warming and the GAP project, cannot be addressed in isolation or by short-term measures or planning. Furthermore, these issues must be addressed through regional and international collaboration. Other concerns, on the other hand, can be resolved individually in a very short amount of time. These include water losses in distribution networks, drinking water quality, irrigation technology improvement, and so on.

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