Al-Muthanna J. For Agric Sci Online ISSN:2572-5149

Print ISSN: 2226-4086

Vol. 13 , Issue 1. 2026

https://muthjas.mu.edu.iq/ http://doi.org/10.52113/mjas04/13.1/14

Climate Change and its Impact on Water Availability and Quality: A Review

Alaa Jabar Mahmoud*,Ansam Saad Al-Khafaji

Department of Environmental Health, College of Applied Medical Sciences, Al-Muthanna University, Al-Rumaytha 66002, Iraq.

***Corresponding Author: alaa.jabar@mu.edu.iq**

Abstract

Climate change is one of the greatest global problems that affect the natural resources, particularly the quantity and the quality of water. The significant effect of climate change on hydrological cycles is due to the changing rainfall pattern, rise in average temperatures, and the increase in severe weather patterns. This analysis examines the impact of climate change on water supply by focusing on the factors of accessibility, quality, and the associated risks to the ecosystems and human health. Results emphasize that adaptive policy and sustainable water management practices are required in order to reduce the intensity of such effects.

Keywords: Climate change, Water Quality, Natural water treatment

Introduction

Water is one of the key elements of life, economic growth and stability of the ecosystem. Climate change has been a source of pressure to the world water systems due to heightened evaporation, glacier melting, extended droughts, and haphazard rainfall distributions. These transformations pose hazards to the amount and quality of freshwater resources especially in arid and semi-arid areas [1].

Water is one of the most significant things in nature. Having 71 percent of water and 29 percent land, it is evident that everything on this earth requires water. Salinity contributes as much as 97 percent of the global water table, with the freshwater sources of water, including lakes, rivers, streams, glaciers, snow, and underground water, contributing only 3 percent of the global water table [2]. Since water can occur on the Earth in the form of solid, liquid, and gases, it makes water a perfect planet with life. In addition, it changes the climate, as it is taken through its numerous changes, distributing energy [1]. Rivers and streams carry water across landscapes and link different areas, while lakes and reservoirs retain water for the long term. Streams are essential for recharging groundwater and supporting habitats, whereas wetlands are like nature's kidneys in that they filter and cleanse water [4].

Water security is the capacity to deal with the hazards to individuals, ecosystems, and economies, which come along with water scarcity, and also to have access to feasible supply of water which meets acceptable water quality requirements in order to sustain human health, economic activity and ecological systems [5]. Water insecurity is the lack of a regular access to adequate, clean and affordable water that is needed to sustain health, livelihoods and social and economic development [6;7].

Studies indicate that the water infrastructure of the region and rural livelihoods are especially sensitive to the impact of climatic variability [6;7]. Research undertaken in East and West

Africa has revealed that families are most likely to be faced with food and water insecurity owing to frequent droughts, erratic rainfall, and inadequate infrastructure [8;9;10].

Paying attention to the interdependence of water resources and climate change, it is essential to be able to adapt to the latter and minimize its impact. This review aims at summarizing the latest studies on the impacts of climate change on water supply and quality.

Water Availability and Climate Change

Among the most urgent issues that attract attention in the present day, climate change deserves to be mentioned, as it influences all spheres of life, and water resources are not an exception. Climate change may have either a positive impact on water resources, that is, an increase in rainfall in certain areas, or negative impact, which is the rise of temperatures above the normal level in other regions, which will lead to an increase in the rate of water evaporation [10]. Numerous definitions have been proposed for the concept of climate change, reflecting the significant attention it receives due to the dangers it poses to both the present and the future [15].

Climate change, according to several studies, is happening right now as a consequence of human activity and is one of the most pressing global problems facing our age and the generations to come. On a worldwide and regional scale, atmospheric temperature is perhaps the most widely utilized indicator of climate change [12]. A considerable amount of the 0.75 degree Celsius rise in average world temperature that occurred in the 20th century was most certainly caused by human activities, namely the release of greenhouse gases into the atmosphere [13].

The term "water availability" describes the quantity of usable and non-usable freshwater in a given area. Only a tiny portion of the water covering the Earth is really drinkable freshwater, even though

water makes up over 71% of the surface [1].

A-Temperature Rise and Evaporation

Rising global temperatures increase evaporation rates from rivers, lakes, and reservoirs, reducing surface water availability. An increase in temperatures also decreases the storage capacity of snow in mountainous areas, causing a rise in the snowmelt earlier and the changes in the seasonal water patterns [2].

Impact on microbial activity an increase in temperature usually raises microbial metabolism and increases biodegradation of organic pollutants. Nevertheless, the presence of extreme heat can decrease the diversity of microbes or cause the death of vulnerable species. Increased evaporation in hot climates may cause pollutant concentration, which makes it more challenging to treat [14].

Evaporation rates: When humidity is low the rate of evaporation is higher and thus can concentrate the pollutants in the water body as well as transpiration humidity of the wetland vegetation has a role in water cycling and uptake of contaminants [15].

B- Changes in Precipitation Patterns

Global climate change has altered the global patterns of precipitation. There are regions where there is more rainfall and floods are experienced and others have extended drought. This variability disrupts water supply systems and increases uncertainty in water resource planning [16].

C- Extreme Weather Events

Extreme events such as hurricanes, floods, and droughts have become more frequent and intense. Floods can damage water infrastructure, while droughts reduce groundwater recharge and surface water storage, increasing water scarcity. Overwhelm natural treatment systems, spread contaminants, and damage infrastructure like wetlands or buffer zones .Droughts reduce flow and dilution, increase residence time of pollutants, and may cause stagnation [1].

Water Quality and Climate Change

A body of surface water's water quality is a direct result of the biogeochemical processes that change the chemical inputs from the air and the landscape into something else entirely [3]. Direct chemical injections into the aquatic system occur as a result of inputs from both natural and human-caused processes, such as air deposition on the water surface or point source pollutant discharge [18]. Rainwater from neighboring watersheds has to go through different parts of the soil, plants, and deep soil ecosystems before it reaches a stream. Along the way, these elements may change the water's chemistry in various ways [11]. One way to measure water quality is by looking at: sensory qualities, such as color and smell or odor, possess physical traits. When evaluating water quality, the following chemical parameters are considered: Parameters pertaining to biological features include things like the concentration of microorganisms including bacteria, protozoa, and algae, as well as conductivity, dissolved salts, and oxygen demand [20]. Rising temperatures and changes in rainfall hydrology, which influence run-off and the mobilization of nutrients and other contaminants, are two ways in which climate change may impact water quality. Physical. Impacts on water quality indicators and deterioration of water quality are the two primary ways in which climate change influences water quality. Surface water systems see a decline in water quality as a result of rising temperatures [19].

Increased Water Temperature

Higher water temperatures lower dissolved oxygen, killing aquatic creatures and fostering algal blooms. These blooms produce pollutants that endanger drinking water [15].

Pollution Concentration

During droughts, lower water volumes concentrate pollutants such as nutrients, heavy metals, and pathogens. This deterioration of water quality increases treatment costs and health risks [21].

Flooding and Contamination

Flood events can wash agricultural fertilizers, industrial waste, and sewage into rivers and lakes, leading to microbial contamination and chemical pollution [21].

Impacts on Human Health and Ecosystems

Poor water quality and limited availability increase the spread of waterborne diseases and reduce access to safe drinking water. Ecosystems suffer from habitat loss, species migration, and biodiversity decline. Wetlands and freshwater ecosystems are particularly vulnerable to climate-driven changes [22].Warmer temperatures and contaminated water increase diseases such as Cholera, Diarrheal diseases, and Typhoid as well as flooding can spread pathogens rapidly, particularly in areas with weak sanitation systems.

Water scarcity affects agriculture, Food Insecurity and Malnutrition reducing crop yields and increasing food prices.Limited water supply reduces sanitation and hygiene, increasing health risks [23].

Impacts on Ecosystems

Rivers, wetlands, and lakes are highly sensitive to temperature and flow changes. Example: The Great Barrier Reef is threatened by rising ocean temperatures and water quality changes, and biodiversity Loss Fish species decline due to low oxygen levels ,wetlands shrink, affecting birds and wildlife altered migration and breeding patterns[24].

Natural water treatment

The effectiveness of various drinking water treatment processes, encompassing selection, design, and operation, is contingent upon the concentration of parameters quantified by metrics such as color and UV absorbance at 254 nm in low turbidity sources[15]. This concentration significantly influences chemical demand and is a critical factor affecting coagulant dosage. Specifically, hemic-like natural organic matter (NOM) fractions characterized by elevated

molecular weight, aromaticity, and hydrophobicity are most susceptible to removal through enhanced coagulation, the primary NOM removal method employed in drinking water treatment. The elimination of NOM is primarily motivated by the reduction of controlled disinfection byproducts, such as trihalomethanes and haloacetic acids, which are generated during chlorination in the presence of residual NOM [17].

Engineered drinking water infrastructure will feel the brunt of the increasing browning and rising NOM trends brought on by climate change. As other causes, such as SO4 deposition, stabilize, recent severe weather events like droughts, wildfires, and floods emphasize the need to evaluate the supplementary effects of climate change on water treatment methods and the quality of raw water. Analyzing the indirect carbon footprints from chemical usage allowed us to examine the influence of raw water NOM trends on the sustainability of treatment procedures at these plants [24].

Adaptation and Mitigation Strategies

1. Equitably maximizing economic and social welfare without sacrificing the sustainability of essential ecosystems is the goal of integrated water resource management (IWRM), a technique that encourages the coordinated development and management of water, land, and associated resources [25].A comprehensive strategy for the integrated management of water, land, and associated resources with the goal of maximizing social and economic wellbeing without jeopardizing the preservation of ecosystem sustainability. [26]
2. Under the increasing demands of a rising population and a changing environment, it is more important than ever to develop better methods of water conservation and storage in order to guarantee a steady supply of water. These techniques improve efficiency, cut down on water loss,

and ensure a steady supply of water in the future.[27]

3. Wastewater treatment and reuse involve cleaning used water from households, industries, and agriculture so it can be safely discharged or reused. This approach reduces freshwater demand, prevents pollution, and supports sustainable water management [28].
4. Early warning systems for floods and droughts are coordinated tools and processes used to detect, forecast, and communicate risks of natural hazards like floods and droughts in advance. Their main goal is to reduce loss of life, property damage, and economic disruption.[29]
5. Climate-resilient infrastructures can endure, adapt to, and recover swiftly from climate-related disasters such floods, droughts, storms, heatwaves, and sea-level rise. It reduces susceptibility and ensures long-term performance and sustainability[11].

Public Awareness and Education

As a result of global warming, hundreds of millions of people are struggling to have access to clean water. The situation is becoming worse as a result of rising demand from cities, energy production, and agriculture, which endangers people's health, economic growth, and food security. The quantity, quality, and dependability of freshwater sources are most impacted by climate change. Droughts and floods caused by excessive precipitation and evaporation endanger water supply infrastructure, which in turn increases pollutants and worsens water quality. A decrease in groundwater recharge in dry areas threatens water and food supplies, which in turn worsens health problems. There will be a worsening of water shortages due to agriculture, which will disproportionately affect vulnerable people including women and girls [30]. The Water Primacy Theory states that the water cycle is the principal pathway via which the effects of climate change will manifest, with subsequent

effects on the availability and quality of freshwater. It demands that efforts to adapt to and lessen the effects of climate change give freshwater the attention it deserves. Extreme weather events and rising sea levels are physical climate threats that amplify other vulnerabilities like pollution and poverty. Already vulnerable regions will feel the brunt of rising water shortages and flood dangers caused by climate change. A change in thinking, doing, investing, and leadership is necessary to solve water-related problems. The effects of climate change on human systems will become more severe if we do nothing. Imminent freshwater shortages might cause a water catastrophe on several fronts, threatening the success of the Sustainable Development Goals [30; 31].

Conclusion

Aquifer supply and quality are both profoundly impacted by climate change. There is a grave danger to sustainable water supply systems from increasing temperatures, changed precipitation, and severe weather events. In order to guarantee water security in the long run, it is necessary to address these concerns via collaborative scientific research, governmental intervention, and adaptive water management measures.

References

1- Davie, T. (2019). Fundamentals of hydrology. Routledge.

2- Ray, R. L., & Tikuye, B. G. (2025). Impact of climate change on surface water resources.

3- Bethancourt, H. J., Swanson, Z. S., Nzunza, R., Young, S. L., Lomeiku, L., Douglass, M. J., ... & Rosinger, A. Y. (2023). The co-occurrence of water insecurity and food insecurity among Daasanach pastoralists in northern Kenya. Public Health Nutrition, 26(3), 693-703.

4- Şen, Z. (2019). Climate change expectations in the upper Tigris River basin, Turkey: Z. Şen. Theoretical and applied climatology, 137(1), 1569-1585.

5- Nan, Y., Bao-hui, M., & Chun-Kun, L. (2011). Impact analysis of climate change on water resources. Procedia Engineering, 24, 643-648.

6- Jepson, W. E., Wutich, A., Colllins, S. M., Boateng, G. O., & Young, S. L. (2017). Progress in household water insecurity metrics: a cross-disciplinary approach. Wiley Interdisciplinary Reviews: Water, 4(3), e1214.

7- Kangmennaang, J., Bisung, E., & Elliott, S. J. (2020). 'We are drinking diseases': Perception of water insecurity and emotional distress in urban slums in Accra, Ghana. International journal of environmental research and public health, 17(3), 890.

8- Brewis, A., Workman, C., Wutich, A., Jepson, W., Young, S., Household Water Insecurity Experiences–Research Coordination Network (HWISE- RCN), ... & Zinab, H. (2020). Household water insecurity is strongly associated with food insecurity: Evidence from 27 sites in low- and middle- income countries. American journal of human biology, 32(1), e23309.

9- Bethancourt, H. J., Swanson, Z. S., Nzunza, R., Young, S. L., Lomeiku, L., Douglass, M. J., ... & Rosinger, A. Y. (2023). The co-occurrence of water insecurity and food insecurity among Daasanach pastoralists in northern Kenya. Public Health Nutrition, 26(3), 693-703.

10- Nti, E. K., Kranjac-Berisavljevic, G., & Doke, D. A. (2025). Water security and sustainability issues in Ghana's Pra River Basin: an introduction–projected usefulness of artificial intelligence. Technological Sustainability, 4(1), 77-97.

11- Nunbogu, A. M., & Elliott, S. J. (2021). Towards an integrated theoretical framework for understanding water insecurity and gender-based violence in Low-and middle-income countries (LMICs). Health & Place, 71, 102651.

12- te Wierik, S. A., Cammeraat, E. L., Gupta, J., & Artzy- Randrup, Y. A. (2021). Reviewing the impact of land use and land- use change on moisture recycling and precipitation patterns. Water Resources Research, 57(7), e2020WR029234.

13- Wang, X., & Liu, L. (2023). The impacts of climate change on the hydrological cycle and water resource management. Water, 15(13), 2342.

14- Yang, D., Yang, Y., & Xia, J. (2021). Hydrological cycle and water resources in a changing world: A review. Geography and sustainability, 2(2), 115-122.

15- Anghileri, D., Pastori, M., Marcos-Garcia, P., Umlauf, G., Crestaz, E., Seliger, R., ... & Carmona-Moreno, C. (2024). Global Water Challenges in Sub-Saharan Africa and how to strengthen science-policy dialogues on transboundary governance and cooperation. Journal of Environmental Management, 365, 121417.

16- Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., ... & Davies, P. (2010). Global threats to human water security and river biodiversity. nature, 467(7315), 555-561.

17- Woolway, R. I., Sharma, S., & Smol, J. P. (2022). Lakes in hot water: the impacts of a changing climate on aquatic ecosystems. Bioscience, 72(11), 1050-1061.

18- Delpla, I., Jung, A. V., Baures, E., Clement, M., & Thomas, O. (2009). Impacts of climate change on surface water quality in relation to drinking water production. Environment international, 35(8), 1225-1233.

19- Whitehead, P. G., Wilby, R. L., Battarbee, R. W., Kernan, M., & Wade, A. J. (2009). A review of the potential impacts of climate change on surface water quality. Hydrological sciences journal, 54(1), 101-123.

20- Moore, K. (2007). Climate change impacts on the catchment contribution to lake water quantity and quality (Doctoral dissertation, Acta Universitatis Upsaliensis).

21- Mwadzingeni, L., Mugandani, R., & Mafongoya, P. L. (2023). Perception of climate change and coping strategies among smallholder irrigators in Zimbabwe. Frontiers in Sustainable Food Systems, 7, 1027846.

22- Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., ... & Zhu, B. (2023). Summary for policymakers. Climate change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change, 3-32.

23- Haggag, M., Kalisa, J. C., & Abdeldayem, A. W. (2016). Projections of precipitation, air temperature and potential evapotranspiration in Rwanda under changing climate conditions. African Journal of Environmental Science and Technology, 10(1), 18-33.

24- Versini, P. A., Pouget, L., McEnnis, S., Custodio, E., & Escaler, I. (2016). Climate change impact on water resources availability: case study of the Llobregat River basin (Spain). Hydrological Sciences Journal, 61(14), 2496-2508.

25- Verweij, W., Van der Wiele, J., Van Moorselaar, I., & Van der Grinten, E. (2010). Impact of climate change on water quality in the Netherlands.

26- Mishra, R. K. (2023). Fresh water availability and its global challenge. British journal of multidisciplinary and advanced studies, 4(3), 1-78.

27- Canton, H. (2021). Food and agriculture organization of the United Nations—FAO. In The Europa directory of international organizations 2021 (pp. 297-305). Routledge.

28- Aduah, M. S., Jewitt, G. P., & Toucher, M. L. (2017). Scenario-based impacts of land use and climate changes on the hydrology of a lowland rainforest catchment in Ghana, West Africa. Hydrology and Earth System Sciences Discussions, 2017, 1-27.

29- Ali, S., Ying, L., Nazir, A., Ishaq, M., Shah, T., Ye, X., ... & Tariq, A. (2021). Rural farmers perception and coping strategies towards climate change and their determinants: Evidence from Khyber Pakhtunkhwa province, Pakistan. Journal of Cleaner Production, 291, 125250.

30- Valavanidis, A. (2022). Extreme weather events exacerbated by the global impact of climate change. Available online: Chem-toxecotox. org/ScientificReviews (accessed on 28 May 2023).

31- Geoffroy, M., Bouchard, C., Flores, H., Robert, D., Gjøsæter, H., Hoover, C., ... & Walkusz, W. (2023). The circumpolar impacts of climate change and anthropogenic stressors on Arctic cod (Boreogadus saida) and its ecosystem. Elem Sci Anth, 11(1), 00097.