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Accessing Drinking Water and Global Warming in Sudan

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Abstract

Sudan's primary water sources are the Nile and non-Nile water resources, including rainfall, seasonal streams, and groundwater, which support a large part of the population. However, water scarcity will worsen with declining rainfall, increasing evaporation, and more frequent extreme weather events due to global warming, affecting rural and urban communities. The climate of Sudan varies from tropical wet and dry in the southwest to desert in the north. From south to north, rainfall drastically declines, and semi-arid regions experience acute water scarcity. In this assessment, we have tried to shed light on the difficulties in guaranteeing sustainable and fair access to drinking water in the face of environmental stressors and offer suggestions for managing Sudan's water resources. To increase agricultural productivity and satisfy the nation's expanding residential and industrial water demands, it is crucial to support the development of water resources for home and agricultural use. Sudan's water resources are multi-sectoral, therefore efficient coordination is essential. Specialized authorities must investigate ways to maximize water usage and set rules to direct and regulate these initiatives.

Key Words: *Global warming, Drinking water, Sudan*

Introduction

A crucial and interrelated component of the Earth's geophysical system, the water cycle affects and reacts to climatic conditions. Earth's radiation balance changes impact cloud dynamics, winds, temperatures, energy, and atmospheric water flow. Temperature changes impact soil moisture and snow-related processes, including melting and snowfall, evaporation and transpiration rates, and cloud characteristics. The occurrence and severity of floods, droughts, and runoff patterns are all impacted by changes in precipitation. These impacts alter plant distribution, growth rates, soil and water conditions, and cloud formation (Tao et al., 2003). Long-term changes in global weather patterns, such as elevated temperatures, modified precipitation, and a rise in extreme weather occurrences, are called climate change. The availability of water resources is one area where these changes significantly impact human civilizations and natural ecosystems (Elsheikh & Nasreldin, 2022).

In sub-Saharan Africa, one of the most urgent issues in urban areas is access to clean drinking water. The situation is worsened by the increasing effects of climate change, especially extreme weather events that alter rainfall patterns and put vulnerable rural and urban households' access to water at even greater risk. Approximately half a billion people worldwide experience severe water scarcity all year, and more than four billion suffer from severe freshwater shortages for at least one month each year (Pörtner et al., 2022). About 2.3 billion people, or 29% of the world's population, did not have access to basic hygiene services, such as water at home, in 2020, according to the WHO/UNICEF-JMP (2021) report. Even though more than 90% of the world's population has access to basic drinking water services (WHO, 2021), sub-Saharan Africa still trails far behind other areas. In rural African villages, piped water is only available to around 5% of the population. By contrast, 54% (about 300 million people) rely on unimproved sources, while 41% rely on improved sources such as wells and boreholes with hand pumps. A major barrier to fulfilling the food and energy needs of the expanding population and accomplishing Sustainable Development Goal 6, which calls for universal access to water, is the pervasiveness of water insecurity (Ayanlade, 2024).

Sudan is Africa's third biggest country, with a landscape that is largely level and has heights between 200 and 600 meters, which is between latitudes 8° and 23° north and longitudes 21° and 39° east, has a "mild desert climate." The northern region experiences the rainy season from July to September for about three months, whereas the southern part experiences it from June to November for about six months. One of the most famous rivers in the world, the Nile flows across Sudan from south to north. At Khartoum, its tributary, the Blue Nile, joins the White Nile. The flow of the Blue Nile is much higher during the rainy season than during the dry season, surpassing the White Nile's normally lower levels (FAO, 2015).

With about half of the Nile River Basin inside its boundaries, Sudan boasts a surface water area of around one million hectares, dominated by a 2,000-kilometer stretch of the Nile and its tributaries. 10% of Sudan is made up of wetlands, while 4% is made up of woods. During the short rainy season, several seasonal watercourses (KHORs)

flow, but their discharge quantities, flow durations, and water quality are not assessed. Perennial rivers beyond the Nile Basin, such as the Khor Abu Habil in Southern Kordofan, the Wadi Azoom, Galol, and other rivers in Darfur, and the Gash, Baraka, and Khor Arbaat rivers in the east, produce an annual discharge of 7.0 BCM (UNEP, 2020). The distribution and availability of water resources in Sudan vary greatly, making management difficult. Climate change worsens This problem, making extreme weather events like droughts and floods more frequent and severe. These difficulties show how urgently the nation needs efficient water resource management plans to guarantee long-term water supply. Thus, we have emphasized in this analysis the challenges of ensuring sustainable and fair access to drinking water in the face of environmental stressors and offered perspectives on managing water resources in Sudan. Improving the development of water resources for household and agricultural use is a top objective to boost agricultural output and satisfy Sudan's expanding need for water for industrial and domestic usage.

Water resources in Sudan

Sudan's primary water resources include surface water sources such as rainfall, rivers, seasonal wadis, Khors, lakes, and wetlands. Groundwater and non-conventional resources like wastewater reuse and desalination are extensively utilized. The country is divided into seven main basins at the watershed level, as depicted in Map 1 (Fanack Water, 2021). Non-Nile water resources play a vital role in Sudan's economy, fulfilling 70% of domestic water needs through rainfall, seasonal streams, wadis, and groundwater. Annual rainfall, averaging 420 billion m^3, has become unreliable since the 1990s, leading to sedimentation and crop failures. Seasonal streams and wadis contribute 2-8 billion m^3 annually but are insufficient for irrigation, while groundwater, recharged at 4 billion m^3 annually, is mainly used for domestic purposes due to its depth. Agriculture, contributing 40% of GDP and employing 80% of the population, relies on rain-fed farming for 90% of cultivated land. Rain-fed agriculture, livestock, and forests collectively contribute over 17% of GDP, support 70% of the population, alleviate poverty, and generate $2.5 billion annually in exports (Bashar, 2019).

Throughout the year, the Nile River and its tributaries provide 73% of Sudan's freshwater supply. With 18.5 billion cubic meters allotted from the Nile's annual supply of 80 billion cubic meters, the 1959 Nile Water Agreement controls Sudan's yearly usage. Most of this water is from the Blue Nile, which rises in Ethiopia and travels through Sudan before entering Egypt. Sudan's Nile system consists of the White Nile, the Atbara River, the Dinder and Rahad rivers, the Blue Nile and its tributaries, and many seasonal streams. There are several seasonal streams in Sudan, which the natives refer to as wadis or khors. The streams usually have a few days of flow from July to October but otherwise stay dry for the rest of the year. The four major streams are shared with neighboring countries: Eritrea shares Gash and Baraka, Chad shares Azum and Hawar, and other streams share South Sudan and the Central African Republic. Other seasonal streams in Sudan include Khor Abu Habil, Wadi El Mugaddam, Wadi Kaja, Wadi Nyala, Alawataib, and Alhawad. The rainfall rate determines the production of most seasonal streams and is not monitored. The average annual flow of the seasonal streams is 5.5 BCM (UNEP, 2020). The annual rainfall in Sudan is estimated at 440 billion cubic meters, with the southern regions receiving the largest amounts, about 800 mm per year. Rainfall decreases northward, with little rainfall between Khartoum and the Egyptian border (120 mm/year). There is a short rainy season with intermittent rainfall in the northern regions. Due to high evapotranspiration rates, rainfall is usually insufficient throughout the year, except for August, September, and October, when runoff helps recharge aquifers and seasonal waterways. However, deforestation exacerbates watershed erosion caused by silt and debris carried by runoff (Omar, 2008). There are also several natural freshwater lakes in Sudan, such as Turdat el-Rahad in Kordofan, Abyad in Southern Kordofan, and Kundi in southern Darfur. Saline lakes may also be found in Sudan, such as Malha in Northern Darfur and the Dariba Crater in Jebel Marra in Western Sudan. With the building of dams, the nation also created artificial reservoirs. These include Merowe in the Northern state, Sennar and Roseires on the Blue Nile, Jebel Aulia on the White Nile, Khashm El-Girba and the Upper Atbara and Setit Complex on the River Atbara, and Lake Nubia in the northernmost section of Sudan, which is a reservoir for the Egyptian High Aswan Dam (UNEP, 2020).

The demands of food security, urbanization, population growth, development, and climate change all put more strain on water resources, making water resources management crucial. Water scarcity is exacerbated by rising demand and pollution, necessitating concerted efforts. The Global Water Partnership defines water resources management as the equitable and sustainable management of land, water, and related resources to preserve ecosystems and optimize economic and social benefits. Fair access to water, effective use, integrated planning, sustainable use, and the development of a fresh approach to water management are among its objectives. According to Bashar (2019), there are still difficulties in establishing sustainable policies and encouraging structural and behavioral reforms for efficient resource use.

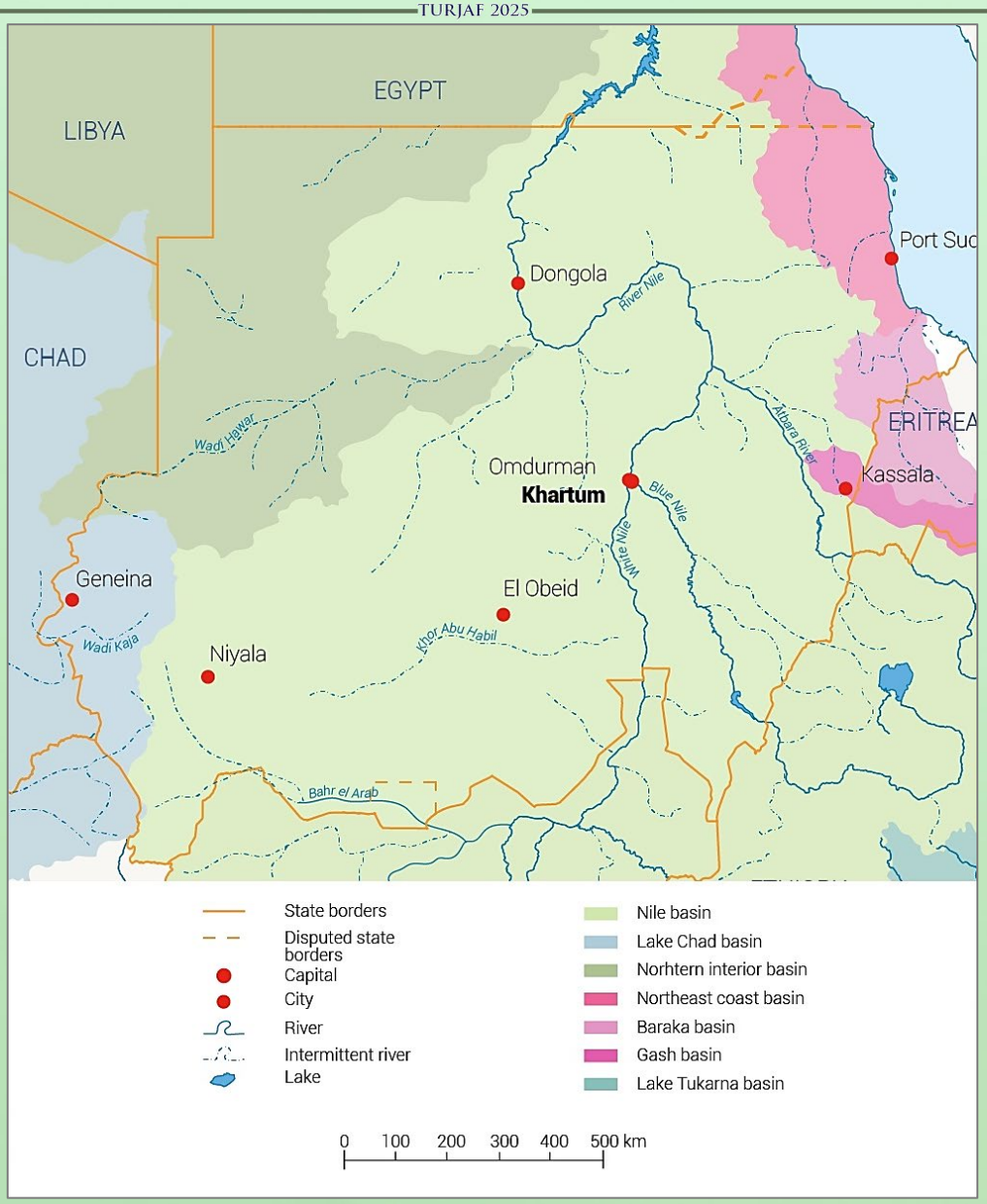

Figure 1. Hydrological basins in Sudan (Fanack Water, 2021).

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Water is an essential and freely available natural resource that sustains life on Earth and plays a crucial role in economic and social development. However, water demand is rising rapidly, particularly in developing nations, due to population growth, urban expansion, industrialization, and agricultural advancements. Irrigation alone accounts for approximately 80% of total water usage, while household consumption is around 10%. As a result, water consumption is increasing at more than twice the rate of population growth, with significant seasonal and annual fluctuations in availability. Additionally, the agricultural sector, historically the largest water consumer, faces growing competition from industrial and domestic demands. This imbalance suggests an impending challenge in ensuring adequate water supply for humans and animals without harming the environment. Moreover, declining water quality is a significant concern, as around 90% of sewage is directly discharged into rivers, lakes, and coastal waters, reducing the availability of clean water. A thorough and organized approach is necessary to overcome these obstacles, enhance water management, and control its usage in developing nations (Omer, 2008). The water cycle, a complex and interdependent component of the Earth's geophysical system, is greatly influenced by climate conditions. Key elements, including wind patterns, temperatures, atmospheric energy distribution, and the movement of clouds and water, are all impacted by changes in the planet's radiation balance (Bağdatli & Arslan, 2019). When freshwater demand in a given area exceeds supply, water scarcity results. Numerous causes, such as population expansion, climate change, and ineffective management of water resources, may contribute to this shortfall (WHO, 2019).

Sudan's water demands are not limited to agriculture; they also include hydropower production, trade, transportation, healthcare, environmental requirements, and industry, mostly agro-based. Despite having a low population density—13 persons per square kilometer on average—more than half of Sudan's population lives on 15% of its territory, mainly in the vicinity of the Nile. 94% of the nation's extracted water is utilized for agriculture, 5% for human and animal usage, and 1% for industry and other uses (Omer, 2008). Reports indicate that Sudan may utilize up to 26 km³ of surface water annually, including its allocated share from the Nile, which is limited to 18.5 km³ per year at Aswan in southern Egypt—equivalent to 20.5 km³ within Sudan before accounting for evaporation and seepage losses—under the 1959 Nile Water Agreement. Additionally, Sudan benefits from 5.5 km³ of water from non-Nile streams. The country heavily depends on the Nile for transportation, agriculture, drinking water, electricity, and recreational activities. Other essential water sources include groundwater reserves and seasonal streams, serving humans and animals (UNEP, 2020). Given the expected impacts of climate change, Sudan must also prepare for increased climate variability and more frequent extreme weather events. Key adaptation strategies include developing policies to mitigate climate change effects, addressing water scarcity through water harvesting, optimizing seasonal streams and rainfall outside the Nile Basin, utilizing groundwater, and cultivating drought-resistant crops. Efficient water management, particularly in irrigated agriculture, is critical to maximizing available resources (Siddig et al., 2020). Water scarcity in Sudan is primarily driven by declining rainfall and rising evaporation rates, threatening food security, rural livelihoods, and public health ((Elsheikh & Nasreldin, 2022). As climate change continues to impact nations worldwide, urgent measures must be taken to minimize its consequences (Bağdatli &Arslan, 2019). Due to the constantly evolving nature of the water industry and fluctuating supply-demand dynamics, Sudan's water policy has changed over time. Limitations like seasonal streams' the Nile's limited storage capacity, and the high expense of pumping groundwater provide serious difficulties on the supply side. Further dam construction is still necessary, especially for harvesting water from seasonal streams, even if the environmental effects of projects must be carefully monitored. Technological developments may enhance the economic feasibility of groundwater monitoring, abstraction, and unconventional water supplies in the future (Omer, 2008). Despite ongoing efforts, millions of Sudanese lack access to clean drinking water. Climate change, inadequate infrastructure, and geopolitical tensions are making water shortages and access to clean and dependable water supplies worse. Regional collaboration, better infrastructure, and sustainable policies are needed to address these issues.

Conclusion

Sudan is facing severe water problems due to climate change-related variables, including rising temperatures and decreasing rainfall. Even though it has a variety of water sources, the amount of water is diminished by siltation, erosion, pollution, and unpredictable rain. To address these issues, Sudan may require costly water projects like dams and desalination plants. Reducing water use, enhancing infrastructure, and using cutting-edge technology are all successful tactics. An ecosystem-based strategy and sustainable management techniques are essential for long-term water security. The Competent authorities should investigate ways to enhance water utilization and create rules to direct and regulate these initiatives. Effective monitoring and adaptation would also be ensured by institutionalizing policy implementation through a robust inspection and audit mechanism. By incorporating sustainable development ideas into laws, Sudan might lessen the effects of climate change and guarantee future water supplies.

References

Ayanlade A. 2024. Safe drinking water supply under extreme climate events: evidence from four urban sprawl communities. *Climate and Development*, *16*(7), 563-578.

Bağdatlı MC, Arslan O. 2019. Evaluation of the number of rainy days observed for long years due to global climate change in Nevşehir/Turkey. *Recent Research in Science and Technology Journal*, *11*, 9-11.

Bashar K E. 2019. *Adapt for Environment and Climate Resilience in Sudan (ADAPT!): Integrated water resources management good practices in Sudan.* United Nations Environment Programme.

Elsheikh W, Nasreldin M. 2022. Impacts of Climate Change on Water Resources in Sudan. *Eurasian Journal of Agricultural Research*, *6*(2), 83-90.

Fanack Water, 2021. *Water resources in Sudan*. Retrieved from https://water.fanack.com/sudan/water-resources-in-sudan/ (Accessed January 27, 2025).

FAO. 2015. AQUASTAT Country Profile – Sudan. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy. Retrieved from https://openknowledge.fao.org/server/api/core/bitstreams/8cb2e0b6-4dd1-46b6-833c-14731c3596d4/content (Accessed January 27, 2025).

Omer A M. 2008. Water resources and freshwater ecosystems in Sudan. *Renewable and Sustainable Energy Reviews*, *12*(8), 2066-2091.

Pörtner H O, Roberts D C, Adams H, Adler C, Aldunce P, Ali E., ... Ibrahim Z. Z. 2022. *Climate change 2022: Impacts, adaptation and vulnerability*. IPCC.
Siddig K, Stepanyan D, Wiebelt M, Grethe H, Zhu T. 2020. Climate change and agriculture in the Sudan: Impact pathways beyond changes in mean rainfall and temperature. *Ecological Economics*, *169*, 106566.
Tao F, Yokozawa M, Hayashi Y, Lin E. 2003. Future climate change, the agricultural water cycle, and agricultural production in China. *Agriculture, ecosystems & environment*, *95*(1), 203-215.
United Nations Environment Programme, 2020. Sudan: First State of Environment and Outlook Report 2020. Retrieved from https://www.unep.org/resources/report/sudan-first-state-environment-outlook-report-2020 (Accessed January 29, 2025).
WHO, 2021. Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs.
WHO/UNICEF-JMP, 2021. Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs.