Impact of climate change on water resources in South Sudan

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Abstract

South Sudan, one of the least developed nations, is vulnerable to the socioeconomic losses and damages brought on by climate change since its people depend on climatically sensitive natural resources for their subsistence. Promoting the gathering and storage of water for various uses is a top concern given the country's recurrent droughts. Water availability may be directly impacted by poor water quality. The goal of this research article is to examine how climate change has affected water resources in order to help South Sudan's future use of water resources. The findings of this work will also be crucial for studies on the Nile River. In South Sudan, both the amount and quality of water have decreased during the previous two decades. This review article also demonstrates how droughts are becoming more frequent and rivers and streams are getting smaller as a result of climate change. Water flow has become seasonal in a number of formerly permanent rivers. Due to poor infrastructure, a number of developmental obstacles brought on by the protracted civil war, and the fact that 95% of the population depends on climate-sensitive natural resources, particularly rain-fed subsistence agriculture and total reliance on forests as a source of energy and other environmental goods and services, South Sudan is particularly vulnerable to the effects of climate change.

Keywords: South Sudan, climate change, water resources, water quality.

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INTRODUCTION

The influence of climate change on water resources is the main area of concern in science and policy because global warming continues to govern the world. According to the 1997 UN assessment of the world's freshwater resources, a third of the world's population resided in nations that were considered to be experiencing water stress and were using more than 20% of their available water supplies. The research went on to predict that by 2025, up to two-thirds of the world's population would reside in nations with water shortages (Jubek et al., 2019).

However, there can be significant regional variations in the impact's characteristics and intensity. Water shortages may occur in some areas. This is projected to cause a significant rise in the population at risk of water scarcity as a result of rising consumption. On the other side, the lives and livelihoods of millions of people may be in danger due to rising sea levels in densely populated coastal areas. In a large portion of the world, droughts and floods will likely become more frequent.

The risk of poverty and hunger will undoubtedly increase due to the high economic expenses and potential loss in crop yield. It is crucial that these effects be assessed with high spatial and temporal precision in order to make long-term strategic plans for a nation's water resources in the face of changing climate change consequences (Abbaspour et al., 2009). One of the most valuable natural resources in the nation is its water resources. The function of water is exposed in parallel to the population's increased dietary needs. One of the essential inputs for agricultural production and for important human life is water (Bağdatlı and Belliturk, 2016; Albut et al., 2018).

Water and climate systems are intricately intertwined. For instance, climate change has an impact on water availability and quality, but it also has an impact on water use. In general, water use, especially irrigation, rises with temperature and falls with precipitation. However, there is no conclusive proof of a historical trend in water use that is related to climate. This is because few water-use statistics and time series are available, and water use is mostly influenced by non-climatic causes (IPCC, 2007). Numerous regional climate models show that rising temperatures and falling precipitation will result in sharp declines in water resources.

Water resources in South Sudan are unevenly distributed both geographically across the nation and temporally since water availability varies greatly from year to year as a result of regular severe floods and droughts. Most of the nation is included in the hydrological basin of the Nile River. Water is stored in broad floodplains, seasonal pools, ponds, rivers, streams, and wetland areas, in addition to perennial rivers, lakes, and wetlands. Given the country's relatively low population, low density, and lack of industrial development, water demand is still low; however, with anticipated population growth and economic development, it is anticipated to rise sharply in the future. The Ministry of Water Resources and Irrigation noted in 2007 that there was already evidence of and growing worry about how human activities were affecting the availability and quality of water resources. Urban regions are experiencing diminishing water tables, decreased river flows, increased pollution, and contamination of both surface and ground waters (MWRI, 2007).

Water is a naturally recharging resource that circulates constantly. The flow of water should therefore be the primary consideration in assessments of water resources, even while water stocks in natural and artificial reservoirs assist in increasing the amount of water resources available for human civilization. The circulation rate of the available renewable freshwater resources (RFWR) is capped by the climatic system. More than two billion people live in extremely water-stressed regions, despite the fact that current global withdrawals are far below the upper limit due to the unequal distribution of RFWR in time and geography. Climate change is predicted to quicken the water cycle, increasing the RFWR that is available. This would reduce the number of individuals experiencing water stress, but adjustments to seasonal patterns and an increase in the likelihood of extreme occurrences would counteract this benefit. The first step in getting ready for such predicted changes will be to lessen current susceptibility (Jubek et al., 2019).

Competition over water has historically been a source of conflict, but it might also be an opportunity for coexistence and peace. The prudent management of Sudan's water resources is seen as a way to promote long-term growth and stability. With efficient institutions and appropriate legislation, water resources could considerably improve the economy, society, and environment (UNEP, 2020). The many facets of climate change in Sudan and South Sudan have been the subject of numerous studies. The two most important climate characteristics and extreme events, temperature and precipitation variations, were the focus of the majority of both the study that was conducted and the future forecasting effort (Nasreldin and Elsheikh, 2022). Consequently, this study was conducted to evaluate the effects of climate change on South Sudan's water resources.

WATER RESOURCES in SOUTH SUDAN

South Sudan is a landlocked nation that occupies 96% of the Nile River Basin in East-Central Africa. It shares borders with Sudan in the north, Ethiopia and Kenya in the east, Uganda and the Democratic Republic of the Congo (DRC) in the south, and the Central African Republic in the west. South Sudan is located in the tropical region between latitudes 3.5° and 12° North and longitudes 24° to 36° East. Its total area is 658842 km2. Huge grasslands, wetlands, and tropical woods dominate the entire nation. Significant agricultural, mineral, water, wildlife, forestry, and energy resources are among its natural assets (Jubek et al., 2019). The country has one of the lowest population densities in sub-Saharan Africa, with less than 13 persons per square kilometer. Seasonal agriculture, pastoralism, fishing, and hunting are the main sources of income in the northern arid zones. The low, wooded savannahs in the middle of the nation offer a variety of livelihood choices. Bahr el Ghazal in the northwest, Equatoria in the south, and Greater Upper Nile in the northeast make up the three areas (formerly historic provinces) that make up the nation. The country originally had ten states, but there are currently thirty-two (MOE, 2015).

The availability of water in trans-boundary river basins' upstream and downstream regions is a very delicate subject. Because South Sudan is situated in the "middle" of the Nile Basin, between the downstream Eastern Nile Countries (Egypt, Ethiopia, and Sudan) and the upstream Nile Equatorial Countries (Burundi, the Democratic Republic of the Congo, Kenya, Rwanda, Tanzania, and Uganda), natural water retention, water withdrawals, and development activities in the countries upstream of South Sudan have an impact on its water quantity and quality (Fernando and Garvey, 2013). Floods and groundwater flow are two ways that lateral water transfer travels from positive to negative places. It is challenging to evaluate the condition of the water flows in the entire transboundary Nile Basin since each individual country and water-use sector in the basin monitors water data, including withdrawals, stocks, wastewater return flows, and groundwater-well yields. Understanding the main water flows and fluxes in the Nile River Basin is made possible by earth observation data at the ecosystem scale (Bastiaanssen et al., 2014).

The Nile Basin's ability to meet future water demands in the region, especially those of South Sudan, is threatened by the amount of water that is used there. Irrigated agriculture uses more than 80% of the water that is withdrawn from the Nile Basin. South Sudan's water withdrawal is quite low in comparison to other nations in the Nile Basin (Jubek et al., 2019). Pre-2011, Sudan's total water withdrawal was estimated by the Food and Agriculture Organization of the United Nations to have been around 27,590 million m3 in 2005. Agriculture accounted for the vast majority of water use, using 26,150 million m3. Municipalities and industry were responsible for 1,140 million m3 and 300 million m3 of withdrawals, respectively. The Food and Agriculture Organization's calculations were based on data for Sudan prior to 2011 and made the following assumptions to arrive at an estimate for water use in South Sudan after that year: the same amount for both South Sudan and Sudan combined; No significant changes had occurred; almost all irrigation is located in Sudan; South Sudan's population was 17% of that of Sudan prior to 2011; and the majority (75%) of industries are situated in Sudan (particularly in the petroleum sector). With agriculture utilizing the most water and a per-person annual withdrawal of roughly 60 m3/year, it is predicted that surface and groundwater withdrawal (primary and secondary) will be about 658 million m3/year after 2011, or about 1.3% of the total renewable water resource. In contrast, yearly water withdrawal per person in Ethiopia is 106 m3, 911 m3 in Egypt, and 714 m3 in Sudan (FAO, 2016; MWRI, 2016).

As water resources become further stressed due to increasing levels of societal demand, understanding the effect of climate change on various components of the water cycle is of strategic importance in the management of this essential resource (Bağdatlı et al., 2015; Elsheikh et al., 2022a). Operational adjustments, demand management, and infrastructural alterations are just a few water management measures that could be taken into account to help with climate change adaptation. The design and operational assumptions used to determine resource supply, system demands, system performance requirements, and operational restrictions may alter as a result of climate change. Depending on the system, several strategy options will be offered for selection, and different options will have different preferences. The following highlights some of the difficulties in determining and putting the adaptation alternatives into practice, as well as some potential techniques that might be taken into account (Levi et al., 2009). Cooperation across big regions that share resources is recognized as an effective policy and management technique for improving water management. Such framework agreements will face further challenges from climate change and rising water demand in the coming decades, potentially leading to more localized conflict. For instance, taking unilateral action to address water shortages brought on by climate change may increase competition for water sources. Additionally, changes in land productivity may result in a variety of new or modified agricultural systems, including intensification practices, which are required to maintain production. The latter, in turn, may result in new environmental stresses that worsen existing environmental conditions and cause siltation, soil erosion, soil degradation, habitat loss, and diminished biodiversity (Meier et al., 2007; Bellitürk and Bağdatlı, 2016; Bağdatlı and Ballı, 2020). Where surface water resources are becoming inaccessible or unavailable, the demand for groundwater resources is likely to rise. Increased groundwater use could result from intensifying irrigated agriculture to accommodate the rising population's demand for food. Even though South Sudan has very few irrigation practices, managing water resources and predicting future demand are essential for the republic's population to remain stable (Jubek et al., 2019).

South Sudan's water resources management, operational adjustments, demand management, and infrastructural alterations are just a few water management measures that could be taken into account to help with climate change adaptation. The design and operational assumptions used to determine resource supply, system demands, system performance requirements, and operational restrictions may alter as a result of climate change (MOE, 2015). Depending on the system, several strategy options will be offered for selection, and different options will have different preferences. The following highlights some of the difficulties in determining and putting the adaptation alternatives into practice, as well as some potential techniques that might be taken into account. The South Sudanese government's water resource management strategy intends to advance the country's understanding and capabilities in water resource mapping, evaluation, and monitoring, to strengthen the water information system, and to advance conflict prevention and sustainable water resource management (MOE, 2015; Jubek et al., 2019).

The national governments of various nations, especially those that are less developed, must implement these crucial measures for water management institutions and policies to address the effects of climate change on water resources: Identify locations at risk of shortages due to climate change by conducting evaluations, which will help guide integrated water resource management; To enhance water availability, encourage the construction of water harvesting facilities such as dykes, water reservoirs, and canals; To increase water availability and quality, upgrade the infrastructure for water and sanitation in metropolitan areas; Create supplemental irrigation systems in rural regions to boost food security and agricultural output;

Create a legal framework that includes penalties for polluting water sources and allows for the monitoring of water quality; To ensure that water quality is maintained, create a sound waste management strategy. The South Sudanese government is gradually implementing water management policies and regulations, but the ongoing conflict, low population densities, and widely dispersed villages and towns make it extremely difficult to provide water facilities, services, and infrastructure in a way that is both efficient and affordable (Wada and Bierkens, 2014; Jubek et al., 2019).

The average surface air temperature around the world has significantly increased since 1970. Based on data from thousands of weather stations, ships, buoys, and satellites across the world, the estimated change in the average temperature of the Earth's surface is calculated. Different research teams independently compile, analyze, and process these measurements. There are several crucial processes in the data processing process (Elsheikh et al., 2022b). Estimates of changes in surface temperature on a global scale have been produced by a variety of research organizations worldwide (FAO, 2016). Other independent observations, such as the melting of Arctic sea ice, the retreat of mountain glaciers on every continent, reductions in the extent of snow cover, earlier blooming of plants in spring, and increased melting of the Greenland and Antarctic ice sheets, support the warming trend that is apparent in all of these temperature records. Since snow and ice reflect solar energy, as they melt, more heat is absorbed, which in turn causes more melting, creating a feedback loop (Trenberth et al., 2007). In addition, since the late 1940s, weather balloons and satellites have been used to measure the temperature above the surface. According to these measurements, the troposphere is warming, which is consistent with the surface warming. Additionally, they show stratospheric cooling. This pattern of stratospheric cooling and tropospheric warming is consistent with how we predict atmospheric temperatures to fluctuate in response to rising greenhouse gas concentrations and the observed ozone depletion (Santer et al., 2008). For a large portion of the world, increased dryness and wetness extremes are predicted, increasing the likelihood of droughts and floods. This has previously been noted, and it is anticipated to persist. With longer dry intervals in between, precipitation tends to be concentrated into heavier events on a warmer planet (Jubek et al., 2019; Bağdatlı and Arslan, 2020).

Around the world, precipitation is not distributed equally. Its average distribution is principally influenced by surface topographical impacts, atmospheric circulation patterns, and the availability of moisture. Temperature has an impact on the first two of these parameters. The amount, intensity, frequency, and type of precipitation have all changed since the 1980s, indicating that human-caused changes in temperature are altering precipitation patterns (Elsheikh, 2021; Bağdatlı et al., 2023). This is why it is expected that these changes will occur in the Republic of South Sudan. In the Republic of South Sudan, traditional subsistence agriculture dominates the economy, with crop cultivation and animal husbandry providing the primary means of subsistence for about 78% of households. Farmers rely on rain-fed agriculture and the application of conventional farming techniques. They become extremely vulnerable to climate change as a result of this combination, especially irregular rainfall. Unfavorable climatic conditions, such as recurrent droughts and yearly flooding, cause losses in livestock and crop production. While flash floods have decimated forests in South Sudan's low-lying regions, particularly those close to the Sudd and Marcher wetlands and the White Nile, droughts are also hastening the expansion of the desert (Jubek et al., 2019).

Global water issues will arise when the effects of climate change spread to other nations. To lessen the effects of global climate change, necessary actions should be taken as soon as possible (Bağdatlı and Arslan, 2019; Bağdatlı and Arıkan, 2020). Finding clean water in the future will be challenging since rising temperatures will cause more evaporation (Bağdatlı and Can, 2020).

It is essential to take steps to prevent the greenhouse effect and global warming in order to reduce the effects of this phenomenon. Cutting back on carbon dioxide emissions could be a solution (Bağdatlı and Can, 2019; Bağdatlı and Ballı, 2019). The Sudd, which is particularly important in regulating the weather patterns in the Sahel region, the Horn of Africa, and the broader East Africa region, is the largest designated Ramsar site of environmental importance and aids in purifying and buffering the excess water. It is located in South Sudan. Water resources are particularly vulnerable to the effects of climate change in South Sudan.

RECOMMENDATION and CONCLUSION

The Republic of South Sudan's government must strengthen the environmental health-related infrastructure to stop the development of water-borne diseases, which will be made worse by climate change as water quality deteriorates and negatively affects availability. The pressure on water resources will increase over the coming years as a result of rising population and water demand, with certain regions of the world experiencing this pressure more quickly than others. Climate change has the ability to both alleviate and increase the burden on water resources. The impact of climate change on water resources is discussed in this essay. It has been demonstrated that the influence of climate change on water resources is extremely sensitive to the scenario for climate change, the scenario for water demand, quality, and quantity, as well as the precise definition of water resource stress.

In South Sudan, both the amount and quality of water have decreased during the previous two decades. Water flow has changed from perennial to seasonal in a number of rivers. Siltation may result from lower water flows. The downstream portion of the river flow holds significant amounts of sediment. Water quality is deteriorating in metropolitan areas as a result of municipal wastewater, sewage, and industrial effluents directly entering water sources due to a lack of wastewater and sanitation management, and contaminated water is to blame for recurrent cases of gastrointestinal disorders and additional serious dangers to water resources.

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