

## EFFECTS OF CLIMATE CHANGE ON SUDAN'S WATER RESOURCES

### A KLÍMAVÁLTOZÁS HATÁSA SZUDÁN VÍZKÉSZLETÉRE

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#### Abstract

*Sudan's water sources vary, as they represent river water, rain water, surface water, and groundwater, depending on where the Sudanese plains split rivers, valleys, and creeks. Sudan faces various water-related challenges such as inadequate sanitation, lack of safe drinking water, pollution, and scarcity. The country's water supply is at risk due to rapid population growth, urbanization, changing consumption patterns, and competing demands from agriculture, industry, and energy sectors. Moreover, the looming environmental changes, including global warming and increased greenhouse gas emissions, are expected to have significant social, environmental, and climatic impacts globally, particularly on water sources. The effects of climate change on Sudan's water resources are a cause for concern as droughts have already begun in some regions. It is therefore imperative to reduce greenhouse gas emissions and adopt clean energy sources while taking urgent and long-term measures to conserve water and mitigate climate change risks. This review highlights the issues related to climate change and its effects on water resources in Sudan, with a particular focus on how changing rainfall patterns will impact agriculture, which is the most critical indirect effect of climate change on water supply.*

**Keywords:** climate change, water resources, Sudan

**JEL code:** Q25, Q54

#### Összefoglalás

*Szudán vízforrásai sokfélék lehetnek, mint pl. folyók, esővíz, felszíni víz és talajvíz, attól függően, hogy a Szudáni-síkság hol választja el a folyókat, völgyeket és patakokat. Szudán számos vízzel kapcsolatos kihívással néz szembe, mint például a nem megfelelő higiénia, a biztonságos ivóvíz hiánya, a szennyezés és a vízhiány. Az ország vízellátását veszélyezteti a gyors népességnövekedés, az urbanizáció, a változó fogyasztási szokások, valamint a mezőgazdaság, az ipar és az energiaágazat versengő igényei. Ezenkívül a közelgő környezeti változások, beleértve a globális felmelegedést és a megnövekedett üvegházhatású gázok kibocsátását, várhatóan jelentős társadalmi, környezeti és éghajlati hatással lesznek világszerte, különösen a vízforrásokra. Az éghajlatváltozásnak Szudán vízkészleteire gyakorolt hatásai aggodalomra adnak okot, mivel egyes régiókban már megkezdődött az aszály. Ezért elengedhetetlen az üvegházhatást okozó gázok kibocsátásának csökkentése és a tiszta energiaforrások alkalmazása, miközben sürgős és hosszú távú intézkedéseket kell hozni a víz megőrzése és az éghajlatváltozás kockázatainak mérséklése érdekében. Ez az áttekintés kiemeli*

*az éghajlatváltozással és annak a szudáni vízkészletekre gyakorolt hatásaival kapcsolatos problémákat, különös tekintettel arra, hogy a változó csapadékeloszlás hogyan befolyásolja a mezőgazdaságot, amely az éghajlatváltozás legkritikusabb közvetett hatása a vízellátásra.*

**Kulcsszavak:** klímaváltozás, vízkészlet, Sudan

**JEL kód:** Q25, Q54

## Introduction

Climate change refers to long-term changes in global weather patterns, including increases in temperature, changes in precipitation, and more frequent extreme weather events (IPCC, 2018). These changes have significant impacts on natural ecosystems and human societies, including the availability of water resources. Sudan is a large nation with abundant natural resources, 80% of the population works in agriculture, which is Sudan's primary source of dependency. It has two primary farming techniques for its agricultural production: the primary one is rainfed, covering over 90% of the agricultural land, while the secondary one involves irrigation (CBoS, 2018; MINISTRY OF AGRICULTURE AND FORESTRY, 2017).

Sudan is at a high risk of being affected by climate change because it relies on rain-fed agriculture and has limited water resources. The country often experiences high temperatures and low rainfall, which puts it in danger of experiencing droughts, floods, and desertification (MUSA et al., 2015). Sudan's management of water resources is being severely affected by changes happening in the country. AMANOR-BOADU et al. (2019) predicts that climate change will worsen the existing water scarcity issues, leading to increased competition for resources and a higher risk of armed conflict. About 44% of the total area of the Nile Basin lies within Sudan borders, constituting almost 75% of Sudan's land area (FAO, 2017), Sudan also shares several aquifers with neighbouring countries for the groundwater resources, such as the Nubian Sandstone Aquifer with Egypt, Libya and Chad, and the Um Ruwaba Aquifer shared with South Sudan, is particularly affected. Sudan currently receives about 18.5 billion cubic meters of water from the Nile, while the amount of rainfall varies greatly across the country, from almost none in the hot, dry north to more than 1600 mm in the tropical south (ABDEEN, 2010; UNEP, 2020).

According to ABDULLA - KARAR (2010), the three primary types of water resources in Sudan are: Surface water: It is found in rivers, streams, lakes, and reservoirs. The major rivers in Sudan are the Nile, which flows through the country from south to north, and its, such as the Atbara and Blue Nile.

Groundwater: This is water that is stored underground in aquifers. Sudan has several aquifers, including the Nubian Sandstone aquifer system, which is one of the largest in the world. Rainwater: This is water that falls from the sky in the form of precipitation. Sudan has a tropical climate, and rainfall varies widely across the country.

In some areas, such as the western region of Darfur, rainfall is very low and drought is common, while in other areas, such as the southern region of Equatoria, rainfall is more abundant. Sudan's national strategy aims to use water resources in various ways to achieve water security, including ensuring enough water for food, drinking, and hydro-energy needs. This strategy also promotes the development of shared water resources in a way that benefits the entire region (ABDEEN, 2010). Sudan experiences great variation in the availability and distribution of water resources, which makes managing these resources a significant challenge. Climate change worsens this situation by disrupting rainfall patterns and increasing the frequency and severity of droughts and floods. A considerable amount of research has been conducted on climate change in Sudan, with most studies focusing on changes in temperature and precipitation, as these are the most critical climate factors and extreme events.

## Data Sources

The sources used for this study included peer-reviewed articles from journals, books, and national presentations, as well as non-peer-reviewed literature from various sources like international and non-governmental organizations, and a few for-profit businesses. The selection of these references was made after an extensive literature search using academic reference systems like Web of Knowledge, Science Direct, and Google Scholar.

### *Climate change and water resources in Sudan*

The rapid heating of the earth due to the greenhouse effect was caused by global climate change, which resulted from the industrial revolution and release of gases such as carbon dioxide, methane, ozone, and nitrogen oxides into the atmosphere (BAĞDATLI - BELLITÜRK, 2016a). Therefore, various policy measures need to be considered to minimize these emissions and reduce the effects of climate change on a national level (MOHAMMED, 2022). Concentration of CO<sup>2</sup> in the atmosphere increases, it can lead to a buildup of heat, causing global temperatures to rise. This increase in temperature can lead to more evaporation of water from the oceans, which can in turn lead to irregular precipitation patterns, including droughts and floods (NASA, 2019). Climate conditions have an effect on the water cycle, which is a dynamic and interrelated component of the planet's geophysical system. Variations in the earth's radiation balance have an influence on a variety of parameters, including winds, temperatures, the transfer of atmospheric energy and water, and cloud dynamics (IPCC, 2013). Water shortage occurs when the demand for water exceeds the quantity of freshwater resources in a certain area or place. This may be caused by a number of causes, including population increase, climate change, and poor water resource management (WHO, 2019). According to the United Nations, more than 2 billion people live in countries with significant water stress, and by 2050, at least one in every four people is expected to be afflicted by recurrent water shortages (UN Water, 2021). Even though there isn't a global water shortage, many areas are facing long-term water scarcity as water demand has been rising at a pace that is more than double the rate of population growth in the last century (MEJÍA, et al., 2012).

Sudan, as a developing country located in Africa, is particularly vulnerable to the impacts of climate change on its water resources (OSMAN - ABDALLA, 2018). It is the third-largest country in Africa and has a population of approximately 45 million people. Sudan characterized by semi-arid to arid climate with high variability in rainfall, making it highly dependent on its water resources (OSMAN - ABDALLA, 2018). Additionally, it is predicted that climate change would bring about more frequent and severe droughts, which will have an influence on how much water is available for home, industrial, and agricultural uses (UNDP, 2019). The annual temperature ranges from 26 to 32°C, with high of over 43°C recorded in summer time in the north of Sudan. The rainy season is unpredictable, with significant differences between the northern and southern areas, less than 50 mm of rain fall yearly in the northern parts, 200 to 700 mm fall in the center regions, and more than 1.500 mm fall in certain southern regions. The rainy season runs from March to October, and the months of June and September have the highest concentration of rain (ALI et al., 2017). According to study, Sudan has experienced a decline in annual rainfall and a shift in the timing and duration of the rainy season. This alteration in rainfall patterns has profound implications for water availability, agriculture, and overall socio-economic development in the country (ELAGIB et al., 2016). According to the Intergovernmental Panel on Climate Change, the water supply would be significantly impacted by 10%–20% decline in precipitation by the end of the twenty-first century. Additionally, IPCC projects that by the end of the century, the country's temperatures would likely rise by 1.5°C to 4°C, which will worsen the effects of water shortages and droughts (IPCC, 2014).

According to reports, Sudan might use 26 km<sup>3</sup> of surface water per year. This includes the water that Sudan is permitted to withdraw from the Nile, which is limited to 18.5 km<sup>3</sup> per year as measured at Aswan in southern Egypt (equivalent to 20.5 km<sup>3</sup> in the center of Sudan before the transportation loss due to evaporation and seepage), as stated in the 1959 Nile Water Agreement (IWMI, 2017). According to ADAM - ABDO (2017), flow from streams not related to the Nile is also included (5.5 km<sup>3</sup>). Sudan primarily relies on the Nile for transportation, leisure, agriculture, drinking water, and electricity. Groundwater reserves and wadis or khors, which are used by both humans and animals, are also important sources of drinking water (UNEP, 2020). This shows that in addition to the anticipated mean climate change, preparedness is also necessary for increases in climate variability and rise in the frequency of severe weather events. The suggested interventions include developing policies and plans to lessen and adapt to the effects of climate change, addressing water scarcity by encouraging water harvesting and making full use of seasonal streams and rainfall outside the Nile Basin, using groundwater, and developing drought-resistant crop varieties; and treating water as scarce resource and improving its efficient use, especially in irrigated agriculture to make the most of the available water (SIDDIG et al., 2020). Water scarcity in Sudan is caused by reduced rainfall and increased evaporation rates, impacting food security, rural livelihoods, and health (SULIEMAN - ELAGIB, 2017). Global water issues will arise when the effects of climate change spread to other nations. In order to lessen the effects of climate change, necessary actions should be implemented now (BAĞDATLI - ARSLAN, 2019). The political leadership is not concentrating on bolstering adaptive governance mechanisms to address the growing threats, which might worsen the situation, even though the Sudan is especially vulnerable to the impacts of climate change on water supplies.

Sudan can benefit from adopting an ecosystem-based approach to manage its inland and marine water resources. This approach involves protecting and restoring healthy ecosystems, which can help reduce the vulnerability of small-holder rain-fed farmers and pastoralists in the face of climate change (Website).

In addition, integrating the principles of sustainable development into all institutional practices can help Sudan achieve its long-term goals. This can be done by ensuring that all policies and practices are aligned with the principles of sustainable development, which include economic, social, and environmental sustainability. By adopting these approaches, Sudan can build climate resilience among smallholder rainfed farmers and pastoralists in the White Nile State, and enhance the resilience of communities living in climate change vulnerable areas of Sudan using ecosystem-based adaptation (EbA) approaches.

## Conclusions

Climate change can affect the availability and quality of water resources adversely and the evidence suggests that causes of climate change are complex, involving both natural forces and anthropogenic activities. Climate change consequences on water resources manifested themselves in such events as flooding, drought, sea-level rise, drying up of rivers, poor water quality, changes in surface and groundwater systems, changes in precipitation and water vapour. Temperature fluctuations have a negative impact on living organisms, and increased temperatures will cause an increase in evaporation levels, leading to water scarcity in the future. Climate change is characterized by a rise in temperature and a gradual decrease in rainfall, which is putting habitats at risk. To reduce the impact of global warming, it is necessary to take measures to prevent the greenhouse effect, and reducing the level of carbon dioxide in the air is one of the solutions that can be implemented. Sudan has a variety of water sources, but there are several factors that affect the quality and quantity of inland water, such as rainfall, siltation,

floods, riverbank erosion, and pollution. Despite this, Sudan is considered to be a nation that is experiencing water scarcity due to unchecked economic growth, pollution, and climate change, which are all putting the country's water supplies at risk. This scarcity of fresh water is a major challenge to global and Sudanese economic development. Furthermore, Sudan is struggling with low and erratic rainfall, which will likely result in the need for expensive water projects such as desalination plants, pipelines, and dams. To combat these challenges, it is crucial to develop both short-term and long-term plans to conserve water. This can be achieved by reducing water requirements and consumption, improving water infrastructure to minimize leaks, and adopting improved water technologies and management practices. Additionally, Sudan should adopt an ecosystem-based approach to manage its inland and marine water resources and integrate the principles of sustainable development into all its institutional practices. To address these challenges, Sudan needs short-term and long-term water conservation plans, including reducing water requirements and consumption, improving water infrastructure, adopting better water technologies and management practices, and implementing an ecosystem-based approach to water resource management. Integrating sustainable development principles into institutional practices is also crucial for Sudan.

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