Eurasian Journal of Agricultural Research 2024; Vol: 8, Issue: 1, pp: 15-23

Threats of Climate Change and Floods in South Sudan

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Abstract

South Sudan, one of the least developed countries, is vulnerable to the losses and social damage caused by climate change since its people depend on climate-sensitive natural resources for their livelihood. Everyone is impacted by fluctuations in a number of climate-related parameters, including variations in temperature and the rate of precipitation. The aim of this review is to investigate the potential threats of climate change and floods in South Sudan. Sea surface temperature shows a positive and negative correlation with rainfall variability. Rainfall varies with time; therefore, skillful monitoring, predicting, and early warning of rainfall events is indispensable. Severe climatic events, such as droughts and floods, are critical factors in planning and managing all socioeconomic activities. Where Excessive rainfall may immediately lead to floods that destroy crops and infrastructure. Floods can have conflicting effects on food security at different spatial scales. The necessity for managing substantial runoff volumes has been identified, with a decade of rainfall data employed to accommodate annual variability. Rainfall spatiotemporal assessment is crucial for water resource management, agricultural productivity, and climate change mitigation.

Keywords: South Sudan, Climate change, Floods, Precipitation.

Review article
Received Date: 14 April 2024
Accepted Date: 13 May 2024

INTRODUCTION

Floods are serious dangers, and in order to lessen the number of lives lost and the loss of livelihoods they cause, adaptation methods are required. Human actions, such as rising development in floodplains and the construction of flood mitigation infrastructure, are altering the regions that experience floods, their characteristics, and the people who are vulnerable to them (Tellman et al., 2021). Improved observations—including more frequent temporal sampling and the capacity to cover wide areas at high spatial resolution—are needed to better comprehend flooding patterns. This sort of information is necessary, for instance, to properly implement suitable flood mitigation measures for a particular location. Due to a paucity of observational data, previous estimates of the populations vulnerable to worldwide floods have been hampered and have instead relied on highly unreliable models. By using satellite data, flood dynamics and extent may be more thoroughly estimated, which in turn helps determine the long-term effects on human populations worldwide. Increased precision in estimations will benefit hydrological models utilized by several stakeholders and numerical models that provide inundation forecasts, lowering uncertainties in such models (Downs et al., 2023). Globally, and especially in developing nations, flooding events are becoming more common due to climate change.

In 2020, record-breaking floods ravaged most of Africa, displacing millions of people across borders, destroying infrastructure, and escalating public health issues within the COVID-19 pandemic. Although flooding is a regular seasonal occurrence in riverine areas of Africa, there is a growing awareness of the extent, magnitude, and duration of flooding as well as its effects, particularly from humanitarian organizations and in relation to ex post relief and ex ante preparation operations (Reed et al., 2022). While global warming persists, the primary area of worry for scientists and policymakers is how climate change will affect water resources. A third of the world's population lived in countries that were deemed to be under water stress and were utilizing more than 20% of their available water supplies, according to the UN assessment of the world's freshwater resources conducted in 1997. According to the study, by 2025, as much as two-thirds of the world's population might live in countries that lack access to clean water (Jubek et al., 2019). Given the limited land available for new agricultural developments and the growing concerns about deforestation and climate change (Bagdatli et al., 2015; Bagdatli & Belliturk, 2016a), many studies have examined the many aspects of climate change in Sudan and South Sudan. Most of the study that was done and the future forecasting effort focused on temperature and precipitation changes, which are the two most significant climatic features and severe occurrences (Nasreldin and Elsheikh, 2022). Flooding has a significant negative influence on agriculture and food security, especially in areas where the seasonality or character of flood episodes may be changing or rising.

Founded on July 9, 2011, South Sudan is the world's newest country. The nation is split into six agro-ecological zones based on geomorphology, which provides a variety of agricultural possibilities (such as maize, sorghum, wheat, and so on) and an abundance of water resources, such as lakes, rivers, and rains. Even with this potential, there is rarely enough grain produced to fulfill demand. A serious barrier to production that lowers yield is the low quality of productive inputs and support services, low-quality and inefficient technologies, and ultimately a lack of infrastructure (Caruso et al., 2017). The South Sudanese subtropical area, which has dense vegetation and frequent heavy rains. In Sudan and South Sudan, seasonal variations in temperature are minimal; nonetheless, precipitation and the duration of the rainy season are sharply declining (Elsheikh, 2021a). Dry north-easterly winds cause practically little rainfall over the nation from January to March. As the wet south-westerly's reach South Sudan by early April, the rainy season begins there. By August, the south-westerly flows approach the borders of Northern Sudan (Mohamed et al., 2021). In South Sudan, an area with a complex ecosystem made up of forests, marshes, and high plant cover that contributes to the flux of moisture into the atmosphere, the rainy season begins first. In Central Sudan, the whole northward movement of moisture from all of these sources is essential to the rainy season. A number of studies and observations document the deforestation and ensuing deterioration of Sudan's natural environment; however, fewer studies evaluate the implications of this degradation for the country's climate (Elagib and Mansell, 2000). Many investigations show that changes in vegetation have a major impact on surface temperature and precipitation in both the southern and central regions of the country. This suggests that land use in Southern Sudan has a major impact on precipitation in Central and Southern Sudan and that deforestation has both local and non-local implications for regional climate. as though For the desert scenario and the grass scenario, the affected region had a reduction in precipitation during the rainy season of around 0.1–2.1 mm d^{-1} and 0.1–0.9 mm d^{-1}, respectively. In the case of the grass and the desert, the surface temperature rises by around 1.2 and 2.4 °C, respectively. Thus, in addition to being local, the decrease in precipitation also affects Central Sudan and its surrounding areas (Salih et al., 2013).

South Sudan has noticed greater effects of climate change, which is changing precipitation patterns and making environmental challenges greater. Therefore, this study examines the risks posed by flooding and climate change in South Sudan.

EFFECT of CLIMATE CHANGE and FLOODS in SOUTH SUDAN

According to Elsheikh et al. (2023), one of the continent's most susceptible to climate change is Africa as a whole. There is ample evidence of the ways in which climate change and extreme weather have affected African nations, particularly those in North, South, East, and Central Africa. Extremes of climate change, in particular warming, and unpredictable rainfall, both in terms of distribution and volume, pose significant development concerns for Africa. El Niño and La Niña are partially responsible for the intensity of the floods and droughts in the Horn of Africa, which includes South Sudan (Haile et al., 2021). In East-Central Africa, South Sudan is a landlocked country that makes up 96% of the Nile River Basin. It borders the Democratic Republic of the Congo (DRC) and Uganda in the south, Sudan in the north, Ethiopia and Kenya in the east, and the Central African Republic in the west. The tropical area that spans latitudes 3.5° to 12° North and longitudes 24° to 36° East is where South Sudan is situated. It is 658842 km2 in total. Throughout the country, vast grasslands, marshes, and tropical forests are the norm. Its natural resources include abundant agricultural, mineral, water, wildlife, forestry, and energy resources (Jubek et al., 2019). With less than 13 people per square kilometer, the country has one of the lowest population densities in sub-Saharan Africa. The primary sources of income in the northern desert zones include pastoralism, fishing, hunting, and seasonal agriculture (Elsheikh, 2021b). Many options for a living are provided by the low, forested savannahs in the country's center. The nation is divided into three parts, once ancient provinces: Equatorial in the south, Bahr el Ghazal in the northwest, and Greater Upper Nile in the northeast (MOE, 2015). Water availability in the upstream and downstream areas of trans-boundary river basins is a particularly sensitive topic. Due to its location in the "middle" of the Nile Basin, between the upstream Nile Equatorial Countries (Burundi, the Democratic Republic of the Congo, Kenya, Rwanda, Tanzania, and Uganda) and the downstream Eastern Nile Countries (Egypt, Ethiopia, and Sudan), natural water retention, water withdrawals, and development activities in the upstream countries affect the quantity and quality of water in South Sudan (Fernando and Garvey, 2013). There are two ways that lateral water transfer moves from positive to negative locations: floods and groundwater movement. Since every nation and water-use sector in the trans-boundary Nile Basin monitors water statistics, such as withdrawals, stocks, wastewater return flows, and groundwater-well yields, it is difficult to assess the state of the water flows throughout the basin. Earth observation data at the ecosystem scale provide comprehension of the principal water flows and fluxes in the Nile River Basin (Bastiaanssen et al., 2014).

Land deterioration, water depletion and pollution, and a lack of grazing might be directly caused by climate change and extreme weather events, including floods, droughts, and temperature swings (Bagdatli et al., 2023; Bagdatli & Balli, 2019). Moreover, it may also refer to secondary biophysical and human-caused risks like warfare, the transmission of illnesses, disruptions of infrastructure and services like healthcare and transportation, and the worsening of the conditions of the weaker members of society. It is anticipated that the effects of extreme weather and climate change will worsen in the future. Because of its subtropical position, South Sudan experiences a lot of rainfall. The region is characterized by year-round heat and is covered in a thick layer of tropical forest and savanna grass (Lukwasa et al., 2022).

Figure 1 shows the observed annual average mean surface air temperature of South Sudan, 1981–2022. Temperatures typically reach highs of over 35°C, especially during the dry season (January to April), and average around 25°C. The capital city of Juba has 34.5°C average highs and 21.6°C average lows annually.

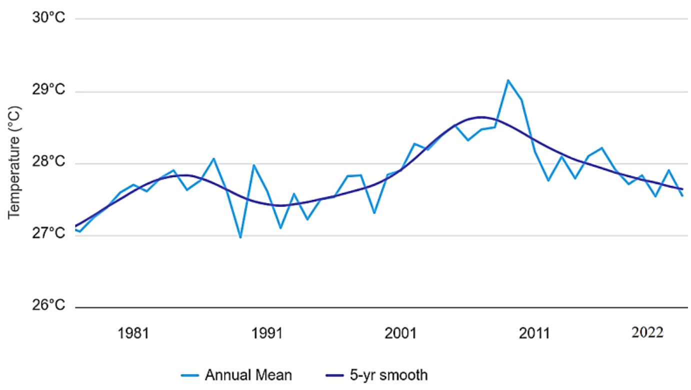

Figure 1. Observed annual average mean surface air temperature of South Sudan, 1981–2022 (World Bank Group, 2021).

There are differences in the amount, timing, and distribution of precipitation in South Sudan. Between 700 and 2200 mm of rain fall there each year. Rainfall quantity and duration often decrease from the country's northeast to southwest regions. Rainfall in South Sudan is unimodal in the northern region and bimodal in the southern, western, and central regions. The northern region of the nation has rainy months from May to October. The first rainy season in South Sudan fell in the country's west and center from April to June, while the second rainy season runs from August to November. While the Central and Western regions of the nation have longer annual growing seasons, ranging from 280 to 300 days, the northern section of the country experiences a shorter annual growing season (130–150 days). Rainfall in South Sudan has been falling and becoming less intense in the north. The cultivation schedule and agricultural choices may be impacted by this (Elagib and Elhaj, 2011). The Inter-tropical Convergence Zone (ITCZ) and the corresponding air mass movement control the amount of rainfall in South Sudan. Tropical south-westerly winds carry precipitation from the Atlantic and Indian seas. The meeting point of the Southeast and Northeast trade winds is this region of low air pressure. The ITCZ travels toward the Southern Hemisphere and reaches South Sudan from September to February. Moist air is driven upward when these winds converge in the area, generating a section of the Hadley cell. Water vapor condenses and descends as rain when the air rises and cools. Wet and dry seasons originate from the ITCZ migrating northward once more between February and May, causing rainfall. This movement occurs in South Sudan (Lukwasa et al., 2022). South Sudan is generally the most vulnerable to political crises and direct and indirect biological and hydro-meteorological disasters brought on by climate change. These underlying causes, in addition to a lack of adaptive ability, have made food insecurity worse and are driving migration and population displacement. Thus, controlling and minimizing the effects of hydro-meteorological hazards and devising community capacity-building intervention methods require knowledge of precipitation behavior and the identification of flood and drought hot spot locations (Colin et al., 2019). In order to provide readers with a general understanding of the geographical and temporal fluctuations in South Sudan's rainfall and to pinpoint regions that are susceptible to drought and flooding, we have attempted to shed light on climate change in this article, particularly as it relates to rainfall.

Evaluating the impact of climate change on different elements of the water cycle is strategically important in the management of this vital resource as water supplies become even more stressed owing to rising levels of societal demand (Elsheikh et al., 2022a; Bagdatli & Arslan, 2019; Bagdatli & Can, 2019). A few water management strategies that could be considered to assist with climate change adaptation include demand management, operational changes, and infrastructure modifications (Bagdatli & Belliturk, 2016b; Bagdatli & Arikan 2020a). Climate change may have an impact on the design and operational assumptions that are used to calculate resource supply, system demands, system performance requirements, and operational limits (Levi et al., 2009; Bagdatli & Balli, 2020). Since 1970, the average global surface air temperature has risen dramatically. The estimated change in the Earth's surface average temperature is computed using information gathered from hundreds of weather stations, ships, buoys, and satellites located all around the world. These measurements are compiled, analyzed, and processed separately by several research teams. The data processing procedure involves a number of important steps (Elsheikh et al., 2022b, Belliturk & Bagdatli, 2016). Numerous research institutions throughout the world have generated estimates of changes in surface temperature on a global scale (Bagdatli and Can, 2020; Bagdatli & Arikan 2020b). The warming trend evident in all of these temperature records is corroborated by additional independent observations, including the melting of the Arctic sea ice, the retreat of mountain glaciers on every continent, decreases in the amount of snow cover, an earlier springtime bloom of plants, and an increase in the melting of the Greenland and Antarctic ice sheets. A feedback loop is created when snow and ice melt because they reflect solar radiation and absorb additional heat as they do so (Trenberth et al., 2007). The risk of droughts and floods is expected to grow throughout a significant area of the planet due to forecasted increases in dryness and wetness extremes. As was previously said, this is expected to continue. Precipitation tends to be concentrated into bigger episodes on a warmer planet with longer dry periods between (Jubek et al., 2019). The required steps should be implemented as quickly as possible to mitigate the impacts of climate change.

The Eastern and Western Flood Plains, which make up the majority of the Northern States of South Sudan and are subject to both droughts and floods, have nearly identical climates, according to Tiitmamer et al. (2018). Additionally, the Ironstone Plateau's conditions are nearly the same across the zone, extending from Juba in the south to Raga in the northwest. The findings show that South Sudan has less rainfall in November and more rainfall in April on average. This is expected since the two distinct seasons—dry and wet—usually begin in November and April, respectively. July and August get the most rain, which is consistent with the nation's long-standing seasonal variations. The yearly rainfall varies greatly, with an average of 53 millimeters in 1990 and 85 millimeters in 2014 (Figure 2). Although it varies depending on the region, the rainy season usually lasts from April to November. Rainfall in the lowland regions of Bahr el Ghazal, the Upper Nile, Jonglei, and Eastern Equatoria ranges from 700 to 1,300 mm per year. About 200 mm are received by Eastern Equatoria's southeast point. The southern upland regions receive the most rainfall, which decreases towards the north. Rainfall in Western Equatoria and the highlands of Eastern Equatoria ranges from 1,200 to 2,200 mm per year (World Bank Group, 2021). Over the course of 45 years, the country has received 69 millimeters of rain on average. Renk had the least amount of rainfall in the region—43 millimeters—as opposed to 84 in Wau and 80 in Juba. When the three stations are combined, the average temperature across the country is around 35 degrees. The monthly average temperature has ranged from 32.11 degrees in August to 38.25 degrees in March. The same data shown annually shows a range of values that are closely grouped together, suggesting little change in the temperature. In a similar vein, there are almost no differences in temperature between the three biological zones—Renk experiences temperatures between 34 and 35 degrees—in Juba and Wau (Tiitmamer et al., 2018). Rainfall that is either above or below normal nationally or in a particular location can cause both regional and national droughts and floods in South Sudan. The Nile River and its tributaries overflow in August and September, which is when flash floods usually occur. Changes in the climate have affected the spatiotemporal distribution of rainfall. Thus, understanding the meso- and micro-level factors contributing to the spatiotemporal rainfall variation should be useful for planning water-development strategies.

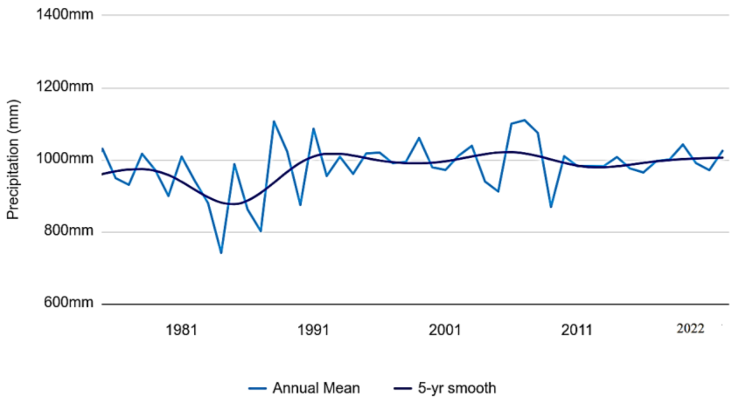

Figure 2. Observed annual Precipitation of South Sudan, 1981–2022 (World Bank Group, 2021).

In South Sudan, the Sudd wetland stretches from south to north. The temperature and amount of precipitation varied greatly. In the southwest, Sudd wetland is wetter and colder; in the northeast, it is drier and warmer. Sudd Wetland is an important environment both locally and globally. The Sudd Wetland, which supports millions of pastoralists and farmers, as well as the internationally renowned Ramsar Wetland, are under pressure from population growth and climate change extremes such as flooding and drought (Zeleke et al., 2024). Previous studies have revealed that the Sudd wetland basin has large-scale seasonal flood events that span between 10 and 30,000 km2. Throughout the rainy season (May to October), flooding happens naturally (Lukwasa et al., 2022). Floods are a potentially catastrophic hydro-meteorological hazard that may kill people and seriously harm livelihoods, infrastructure, and the environment. They can also disrupt services and inflict extensive damage. The flood phenomenon has an impact on the pastoralists living in the Sudd wetland. While the wetland's central and northern regions showed dry events, the wetland's north and south regions showed predominantly wet occurrences. Alternating dry and wet occurrences were also seen in the wetland's central and southern parts. The overall outcome demonstrated an unpredictable pattern of precipitation. This outcome was amply supported by related studies. The Sudd wetland is characterized by an increased frequency of floods and droughts, variable precipitation, and uncertain seasonal timing (Zeleke et al., 2024). The World Food Programme (WFP) of the United Nations has issued a warning, stating that as the country's climate crisis deepens, floods in South Sudan may result in extremely high levels of malnutrition in the first half of 2024. The worst incidences of malnutrition are seen in communities devastated by flooding because of the development of water-borne illnesses, cramped living conditions, and restricted access to food and employment opportunities (WFP, 2023). Since information may be utilized to take preventative steps to enhance resilience to climate change, the study of large-scale seasonal flood occurrences and the potentially catastrophic impacts of floods is particularly essential.

CONCLUSION

With the growing impact of climate change, particularly the wide range of temperatures and the intricate patterns of temporal and geographical variability in precipitation, the dynamics of the atmosphere across the seas and large-scale pressure systems are impacted. Nonetheless, over the previous fifty years, South Sudan's rainfall has both dropped and increased in variability. It has been raised how South Sudan is projected to be affected by climate change, with particular attention paid to rainfall and potential flood hazards in this research. In the absence of planned adaptation and mitigation methods, the repercussions have had an influence on development, livelihoods, and ecosystems. Extreme occurrences like floods may result from this, since seasonal flooding has occurred in many parts of the world, including South Sudan. Thus, in order to adequately prepare for such occurrences, it is imperative to conduct a comprehensive investigation of climatic changes, particularly the catastrophic events that may transpire.

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