Climate Centre

Country-level | Climate fact sheet

Sudan

1. Country overview

Figure 1: Map of Sudan.

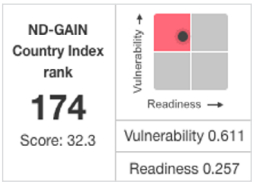

Figure 2: Sudan's ND-GAIN Ranking (ND-GAIN 2021).

Sudan is home to a variety of climate zones, including desert as well as agricultural land and mountains. The country's economy was heavily impacted when South Sudan seceded in 2011, and the subsequent civil war in its southern neighbour has contributed to a large number of refugees and migrants passing through the country (World Bank 2020). Agriculture forms a large part of the economy, responsible for the livelihoods of approximately two-thirds of all Sudanese. Agricultural exports (livestock, sesame, gum arabic and cotton) were 55 per cent of the country's exports in 2019 (World Bank Group 2020).

Sudan ranks 174 out of 181 countries in the Notre Dame Global Adaptation Initiative (ND-GAIN) index. The ND-GAIN index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. This ranking indicates that Sudan has high vulnerability levels, and low levels of readiness to adapt to climate change (ND-GAIN n.d.).

1.1 Climate

The northern part of Sudan is a desert climate, receiving little rainfall. Temperatures peak in

June–September in this region; and, during this hot season, temperatures can range from the high 20s at night to well over 40°C during the day (International Research Institute for Climate and Society (IRI) n.d.). From April to September, there are sandstorms in this desert region (United States Agency for International Development (USAID) 2016). In addition to these sandstorms, droughts and floods are major climate-related hazards in the country (Gudoshava *et al.* 2020).

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The southern part of the country has its rainy season in May–October, and averages about 12 days of rain per month in the rainiest month (August). Temperatures are coolest during this season, with April being the hottest month in the lead up to this rainy season. Even during April, however, daytime temperatures are less extreme than in the north, generally staying below 40°C. The coldest months of December and January can see nighttime temperatures drop below 20°C in this region (IRI n.d.).

Many "rainy" days do not actually rain very much, however, and a large percentage (one-quarter to almost one-half) of the total yearly rainfall comes in extremely heavy rainfall events that dump large amounts of water at once. These are infrequent, happening only a few times per year (Salih *et al.* 2018).

The Nile is a critical water resource in Sudan, and it experiences seasonal high-water levels every year (Davies and Walsh 1997).

1.2 Climate change

Historical Climate	Projected climate
Temperature	
Temperatures have risen in recent decades throughout the country. This includes increases in both average and extreme temperatures. The current climate is about 1.5°C hotter in Sudan now than it was last century (USAID 2016, Osman and Sevinc 2019).	Temperatures are projected to continue to rise with climate change, both average and extreme temperature (USAID 2016). Khartoum will be one of the top five most exposed cities to deadly heat in Africa by the end of the century (Rohat 2019).
Precipitation	
Rainfall in Sudan has gone back and forth over the last 50–75 years, with some decades being wetter than others. The region has had significant variability over time in how much rain tends to fall (Mohamed 2013). Sudan has experienced sea level rise of 10–20 centimetres (cm) along the Red Sea since the early 1900s (Republic of Sudan 2015) Globally, sea levels have risen by approximately 21 cm since 1880 (Church and White 2011)	Many studies expect that rainfall in much of Sudan could increase with climate change (Basheer *et al.* 2016), but there is considerable uncertainty about exactly what this would look like. The rainy season might start later and end later, and it might have more dry spells between rainy days in many parts of the country (Gudoshava *et al.* 2020). Any changes will probably be different in the north compared to the south. The future of the Nile under climate change is uncertain. Some studies project a decline of up to 70 per cent and others an increase of around 15 per cent (USAID2 016; Taye *et al.* 2015). One study suggests that inter-annual fluctuations may also significantly increase (Siam and Eltahir 2017). Globally, sea levels are projected to rise by an additional 20–30cms by 2050 and from 50–200cms by 2100, depending on levels of emissions; with at least one study ranging as high as 280cms (Kulp and Strauss 2019). Therefore, sea level rise poses a significant threat to coastal communities and infrastructure, and increases the risk of saltwater intrusion. Sand- and dust-storms may become more common due to increased desertification and drought (United Nations Environment Programme (UNEP) 2017).

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2.Humanitarian sectors and climate change

2.1 Water and habitat

Water

Climate change will increase heat stress in Sudan, especially in the built environment. Studies project that appropriate building design combined with active air-conditioning is going to be critical in many buildings in Khartoum to manage heat stress by the end of the century (Osman and Sevinc 2019). Traditional Sudanese architecture includes many strategies to manage heat stress in buildings, including roofs that shade themselves, natural ventilation, and mixed open and closed areas. Additional cooling strategies include shading of windows during the hottest parts of the day, dehumidification and air-conditioning. Because much of Sudan is very dry, innovative techniques for cooling buildings, such as two-stage evaporative cooling and solar chimneys, can be low-cost and effective. Covering roofs with reflective paint or material can also reduce heating of buildings from the sun (Osman and Sevinc 2019).

With increased temperatures, it is expected that people will increase the use of air-conditioning in addition to these other strategies for cooling buildings (Osman and Sevinc 2019). This increased use of air conditioning over time will also increase power supply needs to urban areas.

Water and sanitation systems will need to account for potential seasonal ups and downs in water availability in riverbeds, because climate change is likely to alter the timing and distribution of rainfall. While in some years this could increase the availability of water, in other years this could result in prolonged dry spells. Water harvesting is a concrete climate change adaptation strategy that has been promoted, as well as tapping groundwater (Siddig *et al.* 2020). At least half of power supplies in Sudan are derived from hydropower, which can be affected by increased evaporation and changes to water availability with climate change (USAID 2015).

Urban flooding in Khartoum can happen due to excess water coming down the Nile River from upstream, as well as local rainstorms that cause local flooding. When both of these phenomena happen at once, it causes unusual damage (Davies and Walsh 1997). This is a particular concern in rapidly urbanizing areas of Sudan, where flood risk should be included in development choices.

Home to a very large youth population, several Sudanese youth have engaged nationally and internationally to discuss and address climate risks. A number of youth are participating in a "Climathon" incubation project to develop ideas that will address the rising risk of extreme events in the country. Their projects include solutions for deforestation, solar lakes, passive cooling, protecting mangrove forests in Port Sudan, and drainage systems to prevent floods.

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2.2 Economic security

About 50 per cent of Sudanese agriculture is irrigated, so any changes to water supply and distribution will have consequences for the production of food and export crops (Ahmed 2020). The southernmost part of the country is considered the "clay soil zone", and this is where a large amount of irrigated and rainfed agriculture is located (Ahmed 2020). The Nile is the main water source in Sudan, and this is the subject of several international diplomatic negotiations between upstream and downstream countries of the Nile.

More than 90 per cent of water use in Sudan is for irrigation, and the demand for irrigation water will continue to grow with predicted agricultural development, regardless of climate change (USAID 2015). Efficient and climate-resilient irrigation schemes will be critical in the future to make the most use of limited and variable water supplies. An increase in temperature will increase evaporation, so the total amount of available water could decrease (Ahmed 2020)

Even if general trends in rainfall increase in Sudan, rainfall will continue to have its ups and downs, and any major drought events will have large impacts on the economy (Siddig at al. 2020). Agricultural and pastoral livelihoods are particularly vulnerable to shortened seasons, drought events and changes to pasture availability, which can cause tensions between groups (USAID 2015).

Measures that are currently promoted to cope with uncertain water supply in Sudan are characterized in the below table by Fadul *et al.* 2019.

Stakeholder	Before flood measures	During flood measures	After flood measures
Farmers	Land preparation before flood, use of shrubs and weeds, pre-tillage practice, make small earth bunds	Use of shrubs and weeds, digging small ditches to distribute water flow, use lebsha to reduce velocity, use sandbags to close breaches	Sharecropping, cultivate vegetables, increase seeding rate for fodder production, double tillage, wetting seeds, reduction of cultivated area, change crop variety, social system of sharing benefits, delay cropping date, change crop, do not cultivate
Water user Associations (WUAs)	Mesquite clearance, land leasing, pumping groundwater, fixed land system, re alignment of field canal	Laying shrubs downstream, field inlets, flood water spreading at fields, monitoring breaching events, embankment heightening, manage irrigation period between water users' associations (WUAs)	Lottery system for field allocation, change field-spur location if needed
Water managers	Embankments heightening, share some of maintenance activities with WUAs, flexible irrigation plan	Flexibility in water allocation period, close monitoring of flooded areas, manual control of intake diversion, delay of maintenance of inaccessible areas	Water pricing based on actual irrigated area at a fixed rate per irrigation unit (Feddan)[1]

1 Feddan = 4,200 square metres (m^2)

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Ways to improve agricultural productivity include maintenance of irrigation canals and pumps, farm machinery, credit, high-yield crop varieties, drought-resistant crop varieties, and weed/pest control. However, any changes to rainfall are only one part of a complex food system, and the evolution of agriculture in Sudan will also be strongly influenced by global geopolitics, including terms of trade and exchange rates. Several scholars have anticipated an increase in potential conflicts over access to water (Siddig *et al.* 2020).

Livestock contributed 60 per cent of agricultural gross domestic product (GDP) in 2015/2016 (Siddig *et al.* 2020). One adaptation strategy promoted for the livestock sector is to improve land tenure and ownership for people who keep livestock, including protection and the encouragement to use livestock corridors (Siddig *et al.* 2020). Rift Valley fever is a big problem for livestock as well as humans; there was a major outbreak in 2007. Analyses of that event indicate that flooding, rainfall and waterlogging of mud-type soils could have contributed to the breeding of the mosquitos that help to transmit the virus. In the future, there is the potential to use satellite information and remotely sensed vegetation indices (i.e. the Normalized Difference Vegetation Index (NDVI)) to predict the spread of disease (Bashir and Hassan 2019).

2.3 Health

Major health risks include air pollution (dust and indoor cooking) as well as poor sanitation, water quality and hygiene. These drivers lead to a significant number of deaths in Sudan every year. Drought events also cause major health concerns in the country, including food insecurity and the transmission of waterborne disease (WHO 2015).

Epidemic outbreaks are another major health concern in Sudan. This includes cholera, meningococcal meningitis, yellow fever, Rift Valley fever and other types of viral haemorrhagic fever. These diseases are influenced both by human behaviour, including human movement and civil conflict, as well as climate/weather variables. Cholera is heavily influenced by rainfall and water availability, and both flood and drought events can cause major outbreaks. Predictive systems for meningitis outbreaks use weather information such as wind and dust conditions. Transmission of yellow fever is sensitive to temperature and rainfall; projections anticipate that the incidence of yellow fever in Sudan could increase with climate change (Gaythorpe *et al.* 2020). Rift Valley fever increases during periods of rainfall and flooding. Floods affect about 20 per cent of the population on an annual basis (WHO 2015). Malaria is also affected by water availability, especially flooding, and the incidence of severe cases increased significantly after a flooding event in 2013, among children under five years of age, and especially those under one year-old (Elsanousi *et al.* 2018).

Improved disease surveillance and mapping is a key strategy to ensure alerts and early action before outbreaks spread. Sudan's health information system is under continuous improvement, including the monitoring of communicable diseases and reporting information ideally on a daily and weekly basis. Epidemic surveillance is a priority (WHO 2015).

Recent years have seen large investments in improving the accessibility of healthcare throughout the country; however, states experiencing conflict struggle to ensure the availability of healthcare facilities. In these regions, the humanitarian sector provides the bulk of available services (World Health Organization (WHO) 2015).

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2.4 Protection

As of 2019 there were 1,885,752 internally displaced persons (IDPs) and 1,055,489 refugees in Sudan (United Nations High Commissioner for Refugees (UNHCR) 2019). Displaced people and refugees are at distinct risk when it comes to the effects of climate change. This includes flood events that can quickly destroy the limited infrastructure in camps, as well as heatwaves that leave people with few options for cooling and shelter. This is also particularly true when it comes to the spread of communicable diseases, because these groups often encounter crowded conditions and have difficulty accessing clean water and healthcare.

Best practices for working on climate change adaptation in Sudan include structures for conflict resolution and attention to inequalities and exclusions in access to, and control of, water resources. An excerpt from a study on adaptation in Sudan recommends:

1. "Integrating climate change adaptation with wider development and peace-building processes. Technical approaches to environmental security, managed without appreciation of social and political tensions and recognition of the complexity of conflict areas, risk failure, irrelevance or doing harm. This is not least because climate adaptation measures (e.g. migration, expansion of agriculture) employed by, or for one, social group can negatively impact on others.
2. Taking a three-pronged approach to building climate resilience in conflict areas: (i) facilitating conflict resolution; (ii) managing environmental conditions; and (iii) tackling vulnerability and exclusion". (Bronkhorst 2011)

Around the world, people in detention frequently have heightened vulnerability to natural disasters due to: spatial marginalization resulting from prison locations on hazard-prone land and/or isolation from emergency evacuation services; limited to no connections to social networks, which are crucial aspects to hazard resilience; and political marginalization, including lack of policies and services to prevent disaster impacts on imprisoned populations (Gaillard and Navizet 2012). These vulnerabilities, coupled with more frequent and intense disasters due to climate change, may leave prison populations in especially precarious positions to hazards such as extreme heat and floods.

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2.5 Policy

Sudan has signed and ratified the Paris Agreement. The country has also submitted its first (Intended) Nationally Determined Contribution (NDC). The NDC outlines Sudan's commitments to climate change mitigation and adaptation. In it, Sudan has committed to reduce greenhouse gas emissions across a variety of sectors including energy and waste management, while committing to afforestation projects. Adaptation commitments in Sudan's NDC include: strengthening national adaptation policies; strengthening institutional capacity at the state and federal levels; implementing adaptation initiatives; enhancing research, observations and climate modelling; and increasing public awareness. The NDC also outlines priority sectors for adaptation initiatives which include agriculture, water resources, coastal zones and public health (Republic of Sudan 2015).

Sudan's Higher Council for Environment and Natural Resources (HCENR) has established a climate change network, including for adaptation planning in the country, and it serves as the focal point to the United Nations Framework Convention on Climate Change (UNFCCC) (USAID 2015). The Sudan Meteorological Authority (SMA) is responsible for providing weather and climate forecasts, including for floods, droughts and temperature. When it comes to longer term information, the General Directorate for Planning and Agricultural Economics (GDPAE) is responsible for much of the scientific research and discussion, sitting within the Ministry of Agriculture and Forestry.

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