Sudan

The Water-Energy-Food Security Nexus Country Profile

- Sudan is located from 9°N to 22°N in north-eastern Africa; it shares borders with Egypt, Libya, Chad, Central African Republic, South Sudan, Ethiopia and Eritrea as well as the Red Sea.
- Although located in the tropics, the climate extends from a desert climate in the northern regions to a summer-rain climate in the southern regions [1].
- Approximately half of the country (mainly in the northern states) is covered by bare rocks and soil. In the southern regions, agricultural areas, trees, shrubs and herbaceous land cover is dominant [2].
- The second Sudanese civil war lasted from 1983 to 2005, when a peace deal was made. The Darfur crisis started in 2003, and a peace accord with the government was signed in 2010. In 2011, following a unanimous referendum vote, South Sudan gained independence from the rest of Sudan [3].
- Abyei is a disputed area with South Sudan [4] and Bir Tawil and the Hala’ib Triangle are disputed areas with Egypt [5].

Highlighted Nexus-related challenges faced by Sudan:

- Regional conflict and instability have forced millions of people to migrate within the country, forcing more people to face extreme poverty with low water, energy and food securities [10]. Furthermore, civil war and famine in South Sudan has seen vast numbers of people seek safety in Sudan, and cross-border oil flows have been drastically reduced [11].
- The water dependency on water originating outside the country is high, and suitable management of the Grand Ethiopian Renaissance Dam (GERD) will be vital for ensuring that Sudan’s water demands are met [12].
- Approximately 5.5 million people in Sudan face food insecurity and 15.9 million people don’t use at least basic drinking water services [13][14].
- Poor water management contributes to high levels of wastage in the irrigation schemes [15].
- Power shortages are common, hence there is an urgency from the government to increase the country’s energy supply through greater generation from hydropower or imports from Ethiopia [16][17].


**GENERAL INFORMATION**

- **1,879,400 km²** Size [14]
- **40,533,000** Population (2017)[14]
- **2.4%** Population growth annual (2017)[14]
- **34.2%** Urban Population (2017)[14]
- **117 billion US$$** Total GDP (2017)[14]
  - *World average: 10,366* [14]
- **14.9%** Poverty headcount ratio at $1.90 a day (2009)[14]
- **0.354** Gini coefficient[13] (2009)[14] 
  - *Ranked the 39th most unequal of 158 countries rated* [18]
- **0.502** HDI[16] (2017) 
  - *Ranked 167th of 188 countries rated* [19]
- **55.4%** School Enrolment, Primary (2012)[14]
- **53.5%** Literacy rate[17] (over 15) (2008)[14]
- **64.5 years** Life expectancy (2016)[14]
- **44.8%** Infant mortality rate (2016)[14]

**Population growth**[8]

- **1970** 10,281,700
- **1985** 17,210,200
- **2000** 27,250,500
- **2015** 38,647,800
- **2030** 54,842,000

**GNI growth compared to HDI improvement**

- Sudan’s GNI per capita has increased by 620% since 2000 [14]. Despite this increase, poverty is still rife and human development outcomes remain weak [24]. Trade sanctions from the United States of America were placed on Sudan from 1997 and were lifted in October 2017 [11].

**Implementation of the Sustainable Development Goals (SDGs):** [23]

- The government of Sudan has established an institutional structure at the high level with the aim of implementing Agenda 2030 and the SDGs
- The agricultural sector has been identified as a comparative advantage, and the national strategy allocates a minimum of 10% of the government budget to this sector
- Sudan’s high debt burden is considered to be unsustainable

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1. Some statistics are only available from before 2011 and therefore cover the geographic area of both Sudan and South Sudan.
2. The gross national income (GNI) is the sum of a nation’s gross domestic product and the net income it receives from overseas.
3. The Gini coefficient is used as a gauge of economic inequality, measuring income distribution among a population. The coefficient ranges from 0 to 1, with 0 representing perfect equality and 1 representing perfect inequality.
4. The Human Development Index (HDI) measures a country’s overall achievement in social and economic dimensions, using life expectancy, education and per capita income indicators.
5. According to available statistics, the literacy rate has dropped significantly from 2000 to 2008 (the only two data points available). No explanation for such a sharp drop was found.
6. The numbers presented before South Sudan’s independence 2011 present the population of only the states that make up present-day Sudan.
WATER SECTOR

The map in the centre of the page shows that spatial variation of annual mean precipitation, as well as plots of mean monthly precipitation at three urban centres to display monthly variability. Most of the country has a desert climate, and the water dependency on water originating as precipitation from outside the country is extremely high at 96% [1]. The erratic and seasonal nature of precipitation places Sudan at a high water security risk, especially in rainfed areas, and the country is subject to devastating droughts and floods [1][25].

Hydrology: 70% of Sudan lies within the Nile River basin. Khartoum is located at the confluence of the White Nile (which flows from Lake Victoria) and the Blue Nile (with a highly seasonal flow, originating in the Ethiopian highlands) [1]. Climate projections indicate that water flow in the Nile is expected to decrease by 20 to 30% over the next 40 years [29].

Grand Ethiopian Renaissance Dam: At the end of 2018, the construction of the GERD (total volume: 74 billion m$^3$) on the Blue Nile River in Ethiopia is almost complete [30]. If and when in operation, the downstream hydrology will be massively altered [31][32][33].

Water use: 96.2% of all extracted water is used for agriculture, mostly from surface water resources, and the irrigation efficiency is low [1][34]. Groundwater is only used in limited areas, and predominantly for municipal water supply [1]. However, groundwater exploitation to meet increasing water demand is taking place in an unplanned manner, and some problems are overexploitation, reduction of reliable yield and deterioration of quality [35].

Small water reservoirs (called hafirs) are important for water supply in villages and to farmers in remote areas [1].
Access to electricity is low, and there is a large discrepancy between the population with access to electricity in urban areas (70%) and those in rural areas (22%) [14].

55.8% of electricity is supplied by hydropower. Despite their high potential, the exploitation of wind and solar energy is not widespread, and geothermal sources have not been exploited [37].

There are two interconnected grids in Sudan: the Blue Nile and Western grids as well as an additional 14 local distribution networks from thermal generators [40].

Traditional biomass (mainly fuelwood and charcoal) is relied on for most energy needs of the populations, mostly in the countryside, that are not connected to the grids [37].

To address the low electricity access, the Sudanese Electricity Distribution Company is undertaking “The Rural Area Electrification by Solar Energy Project”, which aims to serve over one million households by 2031 [41].

In line with the Paris Agreement, Sudan’s Intended Nationally Determined Contributions include an objective to attain a 20% mix of renewable energy in their power system by 2030 [29]. Plans also exist to increase the country’s hydroelectric power generation [16].

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Fuel production: 75% of Sudan’s oil production fields were lost due to the secession of South Sudan in 2011. Disruptions in oil production have had negative effects on the economies of both countries [40].
Recent estimates state that approximately 5.5 million people in Sudan face food insecurity and the chronic malnutrition rate is 38% [13]. Over 70% of the population depend upon crop production and/or livestock husbandry to support their livelihoods [29].

The major irrigation schemes are the Gezira, Rahad, New Halfa, Elsuki, White Nile and Blue Nile schemes [10].

- Sudan is a net importer of both food and essential agricultural inputs [10].
- On average, Sudanese people spend 61% of their income on food, and food price increases have severe impacts on food security [44].

**Major Agricultural Schemes**

- The major crops in Sudan are cotton, gum Arabic, food crops and oil seeds [21]. Up until the late 1990s, agricultural exports were the main source in foreign income in Sudan, before this was replaced by oil exports [10].
ENVIRONMENT

2.3% of total land area  Protected land areas (2016)[14]

16% of territorial waters  Protected water areas (2016)[14]

Solid waste management and sewage treatment is reported as inadequate in all of Sudan’s cities, with rubbish typically accumulating close to its point of origin [43]. Only 0.6% of the population is connected to a sewerage network [45].

Agriculture is cited as having led to serious environmental problems, including land degradation, riverbank erosion, invasive species and water pollution. Poorly managed rainfed agriculture has been responsible for large-scale forest clearance [43].

Sudan began their first programme to combat desertification in 1978, with the establishment of the National Desertification Control and Monitoring Unit [46]. Three compounding desertification processes are identified as underway in Sudan [43]:

- Climate-based conversion of land types from semi-desert to desert.
- Degradation of existing desert environments.
- Conversion of land types from semi-desert to desert by human action.

In 2016, 55.8% of electricity production in Sudan was from [21]. Therefore, the country’s energy security is highly reliant on river discharges.

Five operational hydropower stations are located on the Blue Nile, White Nile and Atbara River [47].

Sudan regularly faces a power deficit in supply peak hours, and the government plans to increase the hydroelectric power generation capacity by 500MW by 2020 [16].

The planned capacity of the GERD (located in Ethiopia but also shown on the map), is significantly greater than any of the hydropower generation plants located in Sudan. Sudan has agreed to increase electricity imports from Ethiopia when the GERD is operational [17].

Water for Energy

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Energy for Water

Two desalination plants produce 65,000 m³ of drinking water per day in Port Sudan. However, their operation is identified as costly and suffering from continuous breakdowns because of electricity cuts and pump maintenance [50].
**WATER - FOOD INTERCONNECTIONS**

Irrigation schemes are prevalent in the country’s east, while rainfed agriculture is mainly practiced in the south of the country [1]. Some of the major crops (e.g., cotton) are very water-intensive [10]. The high use of pesticides in agriculture has caused to widespread pollution of surface waters and irrigation canals [43].

**Gezira Irrigation Scheme**

The largest irrigation scheme in Sudan is the Gezira Irrigation scheme (with the Managil extension) covering 870,000 ha. It is a gravity irrigation system which accounts for almost 50% of the total irrigated lands in the country [1][15]. The annual irrigation crop season extends from June to March. With such a high crop demand, the Sennar Dam was built to ensure the irrigation requirements would be met [15].

The combined design capacity of the Gezira and Managel irrigation systems is $30.5 \times 10^6$ m$^3$/day. This accounts for one third of Sudan’s share of the Nile waters [15].

Poor distribution of water and management practices are identified as contributing to severe water wastage problems in the scheme. A large amount of sediment entering the irrigation scheme is another key problem [15].

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**ENERGY - FOOD INTERCONNECTIONS**

**Agriculture for Energy**

Biomass plays an important role in the provisioning of energy, with an estimated 51% of energy consumption deriving from this source. South Sudan was the source of most fuel wood and charcoal used mainly for cooking and providing industrial heat, and therefore the secession of the country has affected biomass availability in Sudan [54].

Residuals from the sugar cane industry are identified as a very important source of current and potential biomass [55].

**Energy for Food & Agriculture**

Water pumping techniques are increasingly used in irrigation schemes in Sudan, substituting traditional flood irrigation and water wheel irrigation techniques. In 2000, the irrigated area where pumps were used to lift water was 346,680 ha [1]. Water for irrigation is also often pumped from aquifers [10].

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**Virtual water refers to the amount of water needed for the production of food and other products. It can be separated into green water (water from precipitation that is stored in the root zone of the soil), blue water (water sourced from surface or groundwater resources) and grey water (the fresh water required to assimilate pollutants to meet specific water quality standards).**

**The virtual water trade for Sudan was calculated using values over the time period 1996 to 2005; i.e. before the independence of South Sudan.**
**GOVERNANCE**

- Under the 1959 Nile Waters Agreement, Sudan has the right to use 18.5 billion m³ of Nile water per year [57].
- The Nile Basin Initiative, founded in 1999, is an intergovernmental partnership of the 10 Nile basin countries. Their aims include developing the Nile Basin water resources in a sustainable and equitable way and to ensure optimal resources use [58].
- At the time of the elaboration of this document, there are disagreements between Sudan, Egypt and Ethiopia because of the proposed GERD project [59][60];
  - Sudan has shown support for the GERD project due to its need for electricity generated there, and this support has strained relations with Egyptian officials, who are concerned about reduced water availability for irrigation [61].
  - A study quantifying the impacts of cooperation between Sudan and Ethiopia on the WEF Nexus with GERD operations showed a clear economic benefit to Sudan when cooperating with Ethiopia [12].
- In the agricultural sector, a 5-year Economic reform programme (2015-2019) aims for the sector to achieve self-sufficiency and increase exports [21].
- Sudan shares seven transboundary aquifers with neighbouring countries and there are no sharing agreements over these resources [1].
- The lack of environmental governance in Sudan is said to be exacerbated by a lack of a shared vision or coordination between institutions that are mandated to manage natural resources [62].
- The ongoing dispute about the Jonglei project in South Sudan is an unresolved governance issue related to the water-food Nexus [63].

**NEXUS EVALUATION**

**Applying the Pardee RAND Food-Energy-Water Security Index**

To gain insight into the security level of each Nexus element and the overall resources security, we present the Pardee RAND Index for Sudan. It is calculated the following way:

- The Index is based on availability and accessibility of the resource, and in the case of the water, an analysis of the adaptive capacity is also part of the calculation.
- Normalised scores are derived by assigning a value between 0 and 1, where 0 represents the minimum value and a score of 1 represents the conditions for that sub-index which are sufficient to meet basic needs.
- All three Nexus elements are equally weighted to determine the overall security index value [64].

**Overall Food-Energy-Water Security Index Value:** 0.39
REFERENCES


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