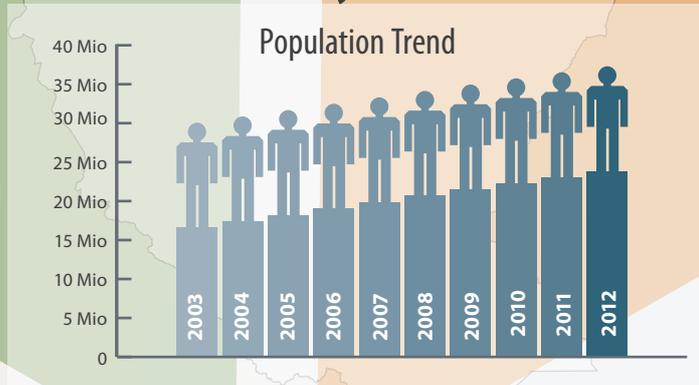


Nexus

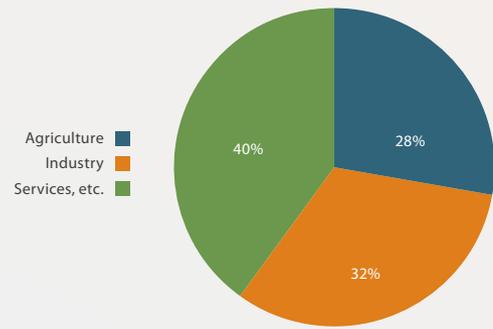
Water | Energy | Food Security

Sudan

Nexus Country Profile



Sector Contribution to GDP, 2008



Investment and Sector Finance

Total land area allocated by FDI (ha): 471,660 to 1,133,100 + 400,000 in South Sudan (signed & under preparation) [6,5]
 FDI capital investment agriculture sector (mio. US\$): 1,045.82 (91.3% Arab countries) (2000-2008) [6]
 Public investment in agriculture (% of GDP): 0.9 (2004) [7]
 [6,5] Deals mainly between governments, main investor Arab Countries with 91% of total FDI; 86.4% of total FDI capital in Khartoum, Northern and Central Sudan; although high increase in total investment- only 2% into agriculture sector, 81% industry, 17% into services, most datasets incomplete [6,4]

Water

Federal expenditures, water (% of GDP): 0.3 (2006) [11]

Energy

Fuel subsidies account for 15% of expenditure in 2012 (IMF cited in eia) [12]

Country Data

Total land area (ha): 237,600,000 [3]
 Population density (people per km² of land area): 20 (2011) [1]
 Population growth (annual %): 2.1 (2012) [1]

 GNI per capita (2005 PPP \$): 1,591 (2012) [2]
 Unemployment total (% of total labour force): 18 (2012) [8]
 GINI coefficient: 35.3 (2011) [1]
 Poverty gap at national poverty line/ at 1.25\$ (PPP) (%): 16/ 5 (2008) [1]
 HDI (value/rank of 187): 0.414/ 171 (2012) [2]
 MPI value: no data available [2]
 GII (value/rank of 148): 0.604/129 (2012)[2]

 Mean years of schooling: 3.1 (2012) [2]
 Literacy rate adult total, 15 and above (%): 72 (2011) [1]
 Life expectancy at birth (total years): 62 (2011) [1]
 Mortality rate under 5 (per 1000 of live births): 73 (2012) [1]

GDP and WEF Sector

GDP per capita (constant 2005 US\$): 836 (2012) [1]
 GDP growth annual (%): 3.1 (2011) [1]

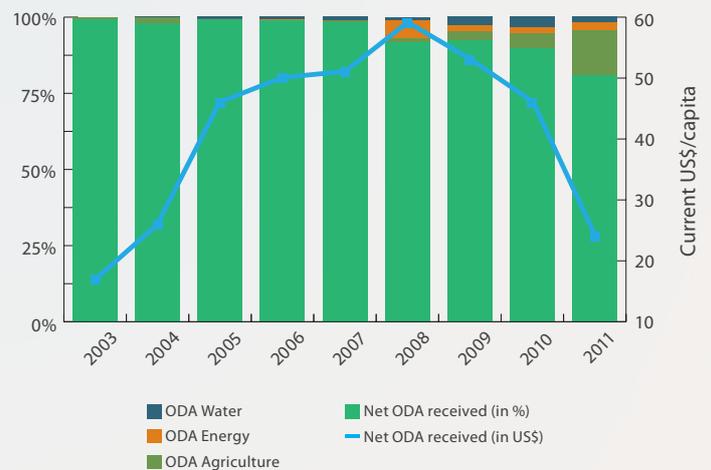
 Government revenues (bio. LCU): 22 (2012) [8]
 Government spending (bio. LCU): 31 (2012) [8]
 Inflation, GDP deflator (annual %): 34 (2012) [1]

 Tax revenue (% of GDP): no data available
 Subsidies and other transfers (% of expense): no data available

Consumption and Foreign Inflows

General government final consumption expenditure (constant 2005 US\$/% of GDP): 4,795 mio. /12 (2008) [1]
 Household final consumption expenditure/ per capita (constant 2005 US\$): 21,731 mio./ 504 (2008) [1]
 Foreign direct investment net inflows (mio. US\$/% of GDP): 56,493.2/4 (2000-2008/2012) [6, 1]
 Net ODA received (% of central government expense): no data available [1]
 Agriculture (source denotes incomplete data)

Official Development Aid in Sectors



Nexus Country Profile Water

Water available per capita: 1.411 m³/a (2011) [1]
 Water consumption per capita: 683.4 (2005) [1]

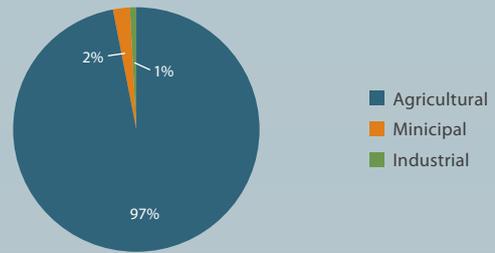
Rainfall average: 416 mm/a [2]
 Rainfall distribution spatial: 25 to 1600 mm/a [2]
 Rainfall distribution temporal: erratic spatial and temporal distribution with rainfall variation coefficient of 0.3 to 1, recent slight decrease in annual rainfall and increased vulnerability due to droughts [2]

Internal renewable water resources
 Surface water : 62.5 km³/a [1]
 Groundwater: 7 km³/a [1]
 Total renewable resources: 64.5 km³/a [1]

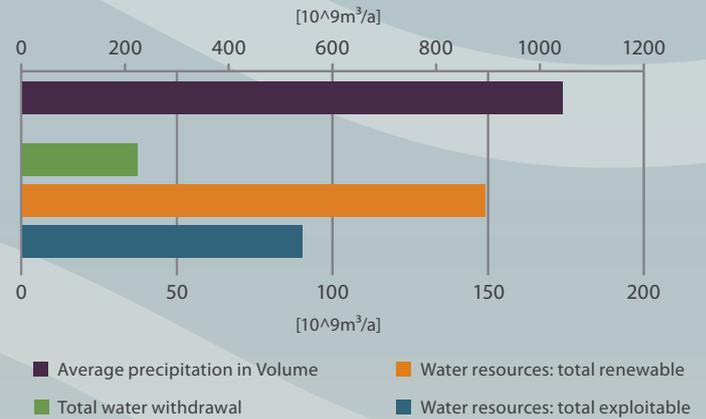
Additional Sources
 Drainage water: no data available
 Treated municipal wastewater: no data available
 Desalination: 2 plants with capacity of 0.024km³/a in Port Sudan [3]

Balances:
 Surface water entering the country, natural: 119 km³/a (2011)[1]
 Surface water leaving the country, natural: 84 km³/a (2011) [1]
 Outflow secured/submitted through treaties: 65.5, 84 km³/a

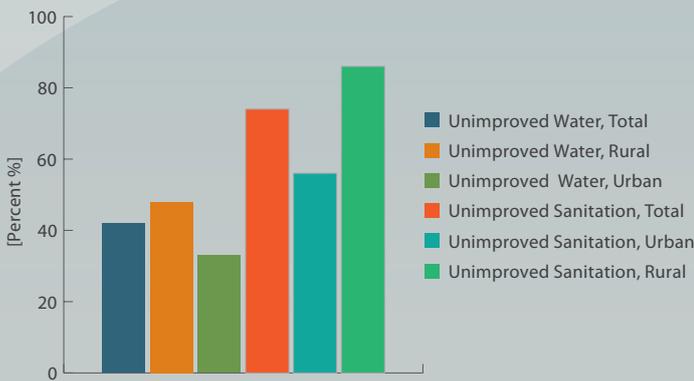
Water Withdrawal by Sector, 2004



Water Resources and Consumption, 2004



Access to Water and Sanitation, 2010



South Sudan has one of the highest infant and child mortality rates in the world with 67 deaths per 1,000, for the North the numbers are slightly lower with 49 deaths per 1,000. Water contamination has several sources and lack of adequate sewage treatment represents one of them. According to the World Bank 43% of the population rely on open defecation. Water borne diseases due to a lack of adequate sewage treatment facilities make up 80% of all reported diseases in Sudan [5].

Water for Energy

Hydropower

Sudan has eight known reservoirs, of which the Shereyk Dam and the Kajbar Dam are under construction. According to UNEP the total designed storage capacity of 8.58 km³ for the larger dams obtains losses in the range of 60% to 34% and results in 6.17km³ [5]. Siltation processes affect all large dams in Sudan except the Jebel Aulia. With the extension of the Roseiries Dam in 2012 the capacity of the reservoir is estimated to 7.4 km³. The main objectives of these reservoirs are flow control and increase of the irrigation potential and secondly generation of electricity. The total and actual numbers on the current storage capacity in Sudan are not available.

Biofuels

Sudan is the third largest sugarcane producer in Africa. Production of biofuels from byproducts of sugar is concentrated mainly on ethanol and secondly on biodiesel. [11] Currently sugar is cultivated on five major irrigation schemes and an area of 200,000 ha. Total production experienced an increase of 77% within 18 years and the government is further planning to expand the area to 1.4 mio ha. A very significant but largely unquantified issue is water pollution and direct discharge of effluent by sugar factories. UNEP reported that the BOD of this wastewater can reach 800 to 3,000ppm and therewith highly affect the water body and fish population.

Deforestation rates in Sudan are high. Although the importance of forests for management of water resources has been widely recognized, deforestation is proceeding. The loss of riverine forests is correlated with increasing sedimentation, high loss in storage capacities of reservoirs, regulation of watershed and increasing vulnerability to floodings[12].

Water for Land/Food

Water Efficiency and Cropping Patterns

A study conducted by El-Amin (2011) reported that water use efficiency in the Gezira scheme is low and overirrigation could be found for each crop analyzed. The yield gap for rainfed crops amounts in 90%[6]. Contrary, AARINENA found out that farmers in Karthoum generally apply too low amounts due to high pumping costs. Cotton, extensively grown in the past, represents the most water consuming crop and experienced a high decrease in cultivation [8]. Sudan as a large country has distinctive vegetative cover and cropping patterns. In the northern part, where rainfall is low, agriculture is based on traditional rainfed farming.

Virtual Water

[10] Mainly livestock affects the balance for virtual water exported with 2503 compared to crops with 652 Mm³/a. Major crops associated with virtual water are cotton, sugar or wheat.

Pollution

Water pollution in Sudan is a chronic crisis due to completely missing treatment facilities and is seen a serious concern in the future. [5] Industrial development in Sudan was low and the environmental damage could have been kept moderated so far.

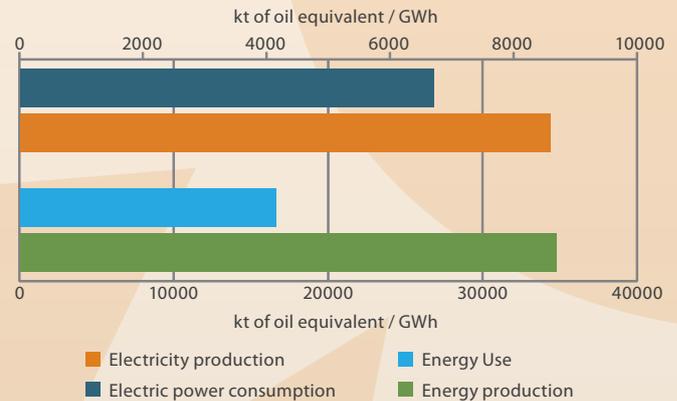
Fertilizer consumption in agriculture of 11 kg applied per ha is low [4]. Subject to many different farming scales and ownerships chemical concentrations and types can vary. UNEP reported that pesticides applied on cotton and wheat fields pose high concentrations of DDT. As monitoring programs do not exist this especially represents a major obstacle and most serious threat to human health in areas, where the population is dependent on this resources for drinking water.

Energy use per capita: 355 ktoe/cap*a (2011) [1]
 Electric power consumption per capita: 143 kWh/cap*a (2011) [1]
 TPES: 16.62 Mtoe (2011) [2]

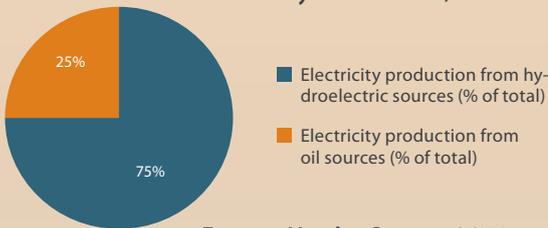
Reserves and Potential:

Crude oil reserves: 5 bio. barrels (75% located in South Sudan) (2013) [3]
 Natural gas: 82.95 billion m³ (2013) [3]
 Coal reserves: None (2007) [4]
 Solar potential: 8,702 TWh (2008) [5]
 Biomass: 15.1 mio. m³(forest wood), 55.5 MW (sugar molasses), plans for 60 mio. l bioethanol and 50 mio. l biodiesel [6]
 Wind potential, wind speed: 0 [5], 3-6 m/s [6]
 Geothermal potential: 400 MW [6]
 Falling water, total hydraulic resources: 48,000 mio. kWh/4,920 MW (2009/n.d.) [7,8]

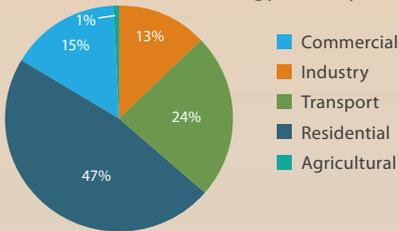
Energy Production and Consumption, 2011



Electricity Production, 2011



Energy Use by Sector, 2011



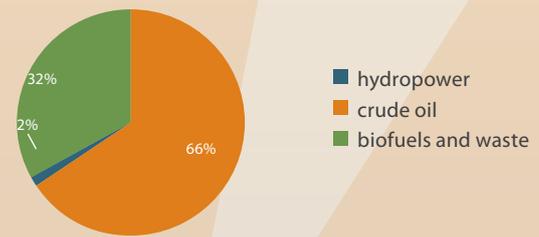
Energy production highly dependent on oil with instability of supply after the independence of South Sudan

- Low access rate to electricity, around 30% in 2011 according to the World Bank.
- Hydropower most viable resource, around 75% of electricity production in 2011 according to the World Bank
- Government plans import energy from Ethiopia and construct new hydropower plants with foreign investments
- High distribution losses (around 22%) not including extreme losses in the dams due to siltation processes.
- Per capita emissions of CO₂ around 0.3 kt with an overall amount of 14,173 kt in 2011.
- Methane emissions in the energy sector resulted in 7,154 metric tons of CO₂ equivalent for 2011. [1]

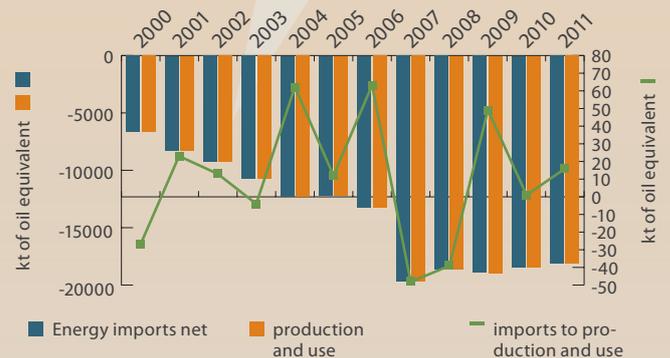
Energy for Water

In Sudan water supply is mainly regulated by diesel driven water pumping units [13]. As in 1980 the demand in conventional energy could not be covered in rural areas, the government decided to enhance the development with the installation of wind pumps for water supply[11]. Water distribution in Sudan is reported to be very cost intensive and thus in recent years there has been a significant increase in renewable energy systems in rural areas in order to reduce the capital cost for energy consumption [14]. While in the past large scale irrigation in agriculture was practiced by gravity systems, pumping technologies became important in the 20th century with flood irrigation and waterwheel techniques [12]. The Gezira scheme is the largest gravity driven irrigation system of Sudan. Within studies of the FAO the area of irrigated agriculture using pumping is indicated in 346,680 ha in 2000 and the area equipped for full or partial control irrigation accounts for 1,730,970 ha. According to estimations calculated by ERAF (2001) 3.6l of diesel are needed to pump 13.9 m³ of water and a head of 50m. Specific data on energy or electricity consumption for water distribution are not available.

Energy Production Sources, 2011



Energy Imports Exports Balance



Energy for Land/Food

Energy Use in Agriculture

The energy use in agriculture is very low with 87 ktoe in 2011 comparing it to international standards. Electricity use in this sector accounts for 26 ktoe while 61 ktoe represent the use of oil products. [2]

Machinization

Investments in agricultural machinery show a steady expansion. In 2004, agricultural machinery in use were 16,639 tractors and increased to 25,564 tractors in 2008 [1]. Mechanized farming in Sudan experienced a high increase with an area of 12.6 mio. ha in 2001 compared to 7.93 mio ha in 1995 [10]. Machinery is used in farming systems with large scale commercial rain-fed cultivation in the dry and wet savanna of Sudan.

Case Study: Gezira Scheme

While in the past large scale irrigation in agriculture was practiced by gravity systems, pumping technologies became important in the 20th century with flood irrigation and waterwheel techniques [12]. The Gezira scheme is the largest gravity driven irrigation system of Sudan. According to studies of the FAO, the area of irrigated agriculture using pumping is indicated in 346,680 ha in 2000 and the area equipped for full or partial control irrigation accounts for 1,730,970 ha. According to estimations calculated by ERAF 3.6l of diesel are needed to pump 13.9 m³ of water and a head of 50m. Specific data on energy or electricity consumption for water distribution are not available.

Nexus Country Profile Land

Agricultural land per capita: 4.15 ha/inh. (2009) [2]
 Cultivated land per capita: 0.61 ha/inh (2007) [2]
 Food production per capita, Gross PIN: 101 (2011) [5]

Agriculture to GDP: 24% (2011) [1]
 Employment in Agriculture: 52% (2011) [1]

Prevalence of undernutrition: 39% (2010-12) [5]
 Share of food consumption expenditure: 61.4% (2009) [3]
 Per capita food supply: 2227 kcal/capita/day (2009)[5]

Production Systems: large irrigation schemes and agropastoral subsistence farming[4], [13]

Main production commodities, quantity: cereals, coare grain, meat (2011)[5]

Main export product, value: sesame, cotton, sheep meat (2011) [5]

Main import product, value: wheat, sugar, coffee (2011) [5]

Land use

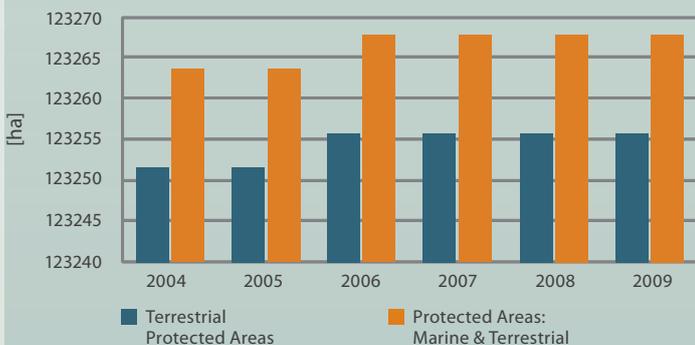


Land for Water

Protected Areas

The proportion of protected areas in former Sudan accounts for 4.2% of total land area [1]. The protected areas differ in terms of type and management between North and South Sudan, but, due to historical and ongoing conflicts, the availability of data is highly skewed. UNEP reported that water pollution is a serious concern. Missing monitoring programs and environmental regulations on protection of water body cause a high threat to the nature and the population.

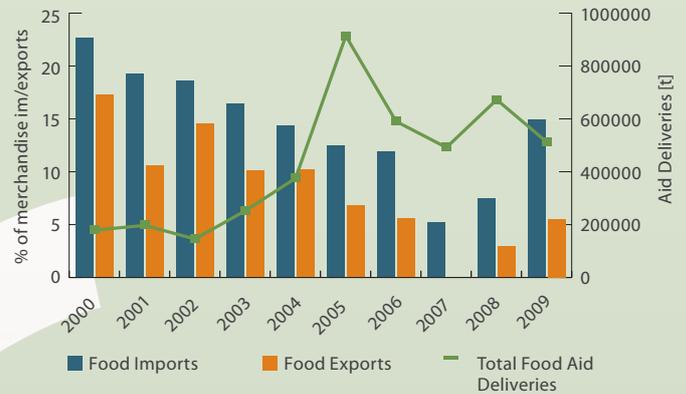
Terrestrial and Marine Protected Areas



Reservoirs

Sudan has in total five hydropower stations and reservoirs, which cover a total surface area known of 3,114 km² [10]. The potential of hydropower is high and several dams are under construction.

Food Imports and Exports



Sudan has a high agricultural potential but due to inadequate water resources and difficulties in transport much of the arable land area is not used. Efforts were undertaken to push the potential and high investment by oil rich neighbours have been carried out since the 1970s to develop Sudan as a major food producer for the Middle East[6]. With the independence of South Sudan the northern part of Sudan has undertaken a lot of investments in pushing forward agriculture to drive the economy and to decrease the dependence on oil as main export product. To establish agriculture large areas of forests were cleared resulting in a severe land degradation and increased vulnerability to droughts and ongoing desertification [9]. Irregular rain affects the yields and causes spatial food deficit. Production of meat and paddy rice had a high increase in the period of 1996 to 2011, while other commodities kept stagnant or decreased such as wheat [5].

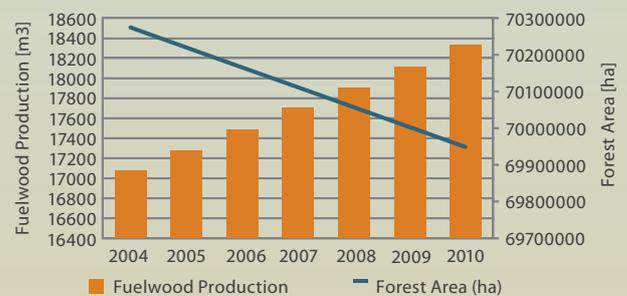
With a poverty ratio of more than 50% living with 1\$ per day, South Sudan belongs to one of the poorest worldwide [1]. Despite the high potential in cultivation, the infrastructure is almost completely lacking and there is no access to markets due to disrupted food corridors. [8] Mostly impact of conflicts, a below average harvest, high production and transport cost and food speculations of food prices are driving the food insecurity in Sudan and the situation is becoming more critical as displacement of people further is causing more severe losses in yields. At the moment in South Sudan 3.7 mio. people are facing acute emergency levels, major food security and nutrition crisis.

Land/Food for Energy

Land for Fuelwood

Biofuels and waste represent one of the major energy source and fuelwood is important as poverty is widespread [1,11]. Deforestation occurs throughout Sudan [9]. Theoretically, forest authorities regulate commercial logging, but in practice this process is much less controlled. In the period between 1990 and 2005, Sudan lost 11.6% of the total forests and deforestation is leading to land and water degradation.

Forest Area and Fuel Wood Production



Land for Biofuels

[12] Biofuels are emerging as an important energy source. Sudan is the third largest sugarcane producer in Africa. Production of biofuels from by-products of sugar is concentrated mainly on ethanol and secondly on biodiesel. Currently sugar is cultivated on five major irrigation schemes and an area of 200,000 ha. Total production experienced an increase of 77% within 18 years and the government is furthermore planning to expand the area to 1.4 mio ha.

Sudan

Rapid Assessment

Overall Assessment

NEXUS CHALLENGES

Sudan continues to struggle with the macroeconomic aftereffects of South Sudan's secession in 2011, as the country lost 75 % of oil output and almost 60 % of its fiscal revenues. Precarious employment and the absence of publicly financed safety nets severely increase the impacts of food, energy and water insecurity on the population.

At least 70 % of the Sudanese population relies on traditional rainfed agriculture and livestock production for food and income. Constant rural-urban migration weakens the agricultural productivity and deepens poverty in both urban and rural areas. As urban populations continue to grow, competing demands for urban and agricultural uses of water increase the stress on the already declining water resource. Hence, problems of irrigation as well as transportation remain the greatest constraints to a more dynamic agricultural economy.

Yet, the farming practices have reduced the arable soil, and have caused desertification to spread. Continuous deforestation due to logging of firewood further increase these effects and lead to severe land degradation. Moreover, the loss of riverine forests increases siltation of reservoirs that reduces their holding capacity and their use for agriculture as well as energy production.

In addition, climatic phenomena like the El Nino warming impact Sudan's heavily rain dependent food security.

Serious concerns for the future of water security in Sudan are raised due to the changing water use of the upstream countries, as well as by the constant water pollution due to the absence of treatment facilities.

SOLUTIONS

Conflicts over natural resources have to stop, cooperation and environmental governance has to increase

Natural resource assessment and management strategies should be increasingly included into peace building and peacekeeping efforts.

It is widely agreed that the primary users – those who directly depend upon the natural resource for their livelihood, for example farmers and pastoralists in the case of Sudan – should have the greatest entitlement.

Renewable energy systems in rural areas can become a viable low cost energy-supply option.

In regard to land issues, it is important to put hold to increasing deforestation by providing alternative energy production technologies. Besides, the economic importance at livestock an pastoral livelihoods must be recognised. This is ensured by taking account of customary procedures in NRM, and reinstating endogeneous mechanisms for conflict arbitration and resolution.

Water Security

The livelihood of Sudan depends on its water security. Eighty percent of the country works in agriculture, which accounts for 97% of its water use. Sudan has a very high water use per capita (1,897 m³/a) and suffers from a water deficiency and cannot cover its water demand for agriculture and other essential uses. With population growth the water demand is expected to double until 2050.

Most of Sudan's currently accessible Groundwater is shared with surrounding countries. Sudan utilizes shares of the water from the Nile river, but its use is not regulated by the government. This unrestrained use of shared water, mostly for irrigation and energy, creates tension with neighbouring countries like Egypt and Ethiopia.

Water security on a household level is affected by a lack of adequate sewage treatment facilities. Water borne diseases make up 80% of all reported diseases in Sudan and cause the highest infant and child mortality rates in the world with 49 deaths per 1,000.



Water supply

High access to safe water through diesel and wind driven pumps, whereas 43% of the population rely on open defecation.



Virtual water

Livestock negatively affects the balance of virtual water exported.



Protected Areas

Missing monitoring programs and environmental regulations on protection of water bodies cause a high threat to nature and the population.



Reservoir

High loss in storage capacities of reservoirs due to increasing sedimentation.



Pollution

High discharge of untreated excreta into water bodies, pollution of groundwater and high concentrations of DDT in potable water storages due to the use of pesticides in agriculture.



Energy Security

Sudan's oil-dependent energy security was severely weakened when it lost most of its oil reserves following the separation of South Sudan. The Government plans to import energy from Ethiopia and construct new hydropower plants with foreign investments. However, high distribution losses occur in addition to high losses in the dams, due to siltation processes.



Biofuels

Biofuels are emerging as an important energy source.



Land for Biofuels

Existent plans to expand the area from 200.000 ha to 1.4 mio ha. Effects on soil quality not assessed.



Fuelwood

Fuelwood is an important energy source as poverty is widespread. Deforestation rates in Sudan are high.



Hydropower

Hydropower is the most viable resource. Its potential is high. Further dams are under construction. There is a need for comprehensive environmental assessment.



Fossil fuels

High oil-dependency. Access to Fossil fuels is a source of conflict between South Sudan and Sudan.



Access to Electricity

Low access rate to electricity, around 30% in 2011.



Food Security

Food security in Sudan is threatened by a combination of conflict, insecurity lack of infrastructure, lacking access to markets and high food prices. Food assistance is delivered to four million people in Sudan, of which the large majority are conflict-affected people. Still, the agricultural potential in Sudan is not exploited.



Cropping patterns

In the northern region agriculture is based on traditional rainfed farming. Cotton as traditional crop experienced a high decrease in cultivation.



Energy use in Agriculture

The energy use in agriculture is very low compared to international standards.



Water use efficiency

Most farms are rural and fed by rainwater. Overirrigation in the Gezira scheme due to technical deterioration and management failures.



Food markets

Cotton and gum Arabic are the major agricultural exports. Live-stock exports to Egypt, Saudi Arabia, and other Arab countries. Local markets are not functioning.



Machinization

Much of Sudan's land is cultivated by mechanized farming. This intense agricultural system has reduced arable soil. Mechanization needs to increase to improve productivity.



Productivity in Agriculture

Subsistence farming and pastoralist communities. Rural-urban migration weakens the agricultural productivity.



Food supply

High child malnutrition at 31.8% and 28% of population below the minimum level of dietary energy consumption in 2010.



Rating

The rapid assessment of the situation above, based on available data, was established following the UN Water Country Profiles. It provides an overview of trends according to the following:

- ○ ○ ○ ○ *insufficient data*
- ○ ○ ○ ○ *trends are of significant concern*
- ● ○ ○ ○ *trends are of concern*
- ● ● ○ ○ *trends are stable or, progressing on certain issues but not on others*
- ● ● ● ○ *trends show some measure of improvement in all relevant indicators assessed*
- ● ● ● ● *trends show significant improvement and there is no concern*

Nexus

Water | Energy | Food Security

Sudan

Nexus Country Profile

About and Copyright:

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<https://www.th-koeln.de/>

<http://www.water-energy-food-nexus.info/>

Useful Resources:

Data Sources:

World Bank Country Database
IEA Statistics
FAO Country Profiles Database
FAO Aquastat Database

Nexus Websites:

www.water-energy-food.org
www.thenexusnetwork.org
www.gracelinks.org
www.futureearth.org