Netherlands Enterprise Agency

East Sudan Horticultural Study part. 1

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East Sudan Horticulture Study

Assignment of: **Netherlands Enterprise Agency (RVO)**

Royal Dutch Embassy in Khartoum

April 2017

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Carried out for: AgroFair RIGHT FROM THE PRODUCER — TASTE Developing Sustainable Trade

Table of Content

Acknowledgment

We would like to thank all informants in East Sudan for their willingness and openness to meet and discuss the issues they face in their daily life as growers of fruits and vegetables. In particular we like to thank Mrs. Ester Loeffen for her efforts to overcome all issues to get the mission started, the company WAS-Trading and Impact Hub Khartoum for facilitating our visit, Mr. Awad Elkarim Elsheikh for taking care of us during the field trip, Mr. Ali Abbas for being our resourceful and dedicated guide through the mission and Mr. Osman El Sheikh for providing many insights and connections into the actual horticultural practice in the region.

Executive summary

The horticultural sector in East Sudan has potential for development. With access to water and suitable land, horticultural production from the region can be produced for the growing internal population in particular the fast developing urban areas like greater Khartoum, as well as for export markets like the Arab peninsula, neighbouring countries (Chad, Libya, Eritrea) and even Europe for some specific crops.

Identified opportunities include the improvement of efficiency in current production practices (use of better seeds, adapted varieties, irrigation practices, nutrient management), investment in post-harvest handling, investment in processing of fruits & vegetables and direct sales of fresh products to urban consumers in particularly during the off-season. The local climate conditions favour the production of organic products. Moreover, local climate conditions in combination with access to water allow for multiple harvests per year.

To tap this potential a long term approach will be required with the active involvement of the private sector and a supply chain approach: organizing the initiative including quality plant material, suitable production sites with sustainable access to water, practical production information and know-how, post-harvest handling facilities, quality standards and sales & marketing arrangements. The success of a future initiative will depend whether these identified bottlenecks along the supply chain can be overcome.

Several ideas for business development have been identified from the identification mission in February 2017 and the reviewed background documents.

A. *Stimulate joint producer initiatives to link market demand to production:*
   These initiatives can range from joint supply with own organized transportation, joint collection, sorting, packing and storage of one or several products, joint planning of production, organization of farmer's markets in main urban areas to the creation of direct sale platforms using internet and mobile phones.

B. *Foster local processing of surplus production of vegetables and fruits:*
   As local investment capacity is limited and external credits difficult to obtain there should be catered for low costs solutions. Drying of fruits and vegetables using locally available resources (sun, solar energy and charcoal of mesquite) is such an option. Another option is the investment in juice processing in particular for Kassala region. Essential will be to take a business approach involving local investors.

C. *Develop single crop supply chains with potential:*
   Several crops with market potential include onion, carrot, tomato, sweet pepper and eggplant for the off-season (Tokar), sweet potato and galia melons.

The realization of the identified potential would benefit from a supportive and active government policy. Supportive actions and measures should include:

1) Facilitation of practical training and demonstration,
2) Stimulation of water saving technologies,

3) Fostering the use of healthy plant material and increasing the access to new varieties,
4) Stimulation of active nutrient management in particular the use of organic manure and compost,
5) Stimulation of the development of agroforestry.

Multiple chances for Dutch business in the (East) Sudanese horticulture can be found. Opportunities exist for:

1) Training and knowledge transfer,
2) Supply of vegetable seeds,
3) Biological crop production products and soil enhancing products,
4) Water storage and water saving solutions,
5) Post-harvest handling,
6) Agro-logistics.

1. Introduction

AgroFair is a Dutch import and export company of tropical (organic) fairtrade fruits and vegetables produced by small producers. TASTE is a foundation of AgroFair, involved in technical assistance for sustainable trade and environment. In 2013, AgroFair as well as TASTE assisted in a study and pilot project, funded by the Common Fund for Commodities and assigned to Bioversity International.

Because of this experience, AgroFair-TASTE has been asked by The Royal Dutch Embassy in Khartoum and Rijksdienst voor Ondernemend Nederland (RVO) in The Hague, to carry out a scoping mission to the Eastern regions of Sudan (Red Sea state, Kassala state and Gedaref state) to identify the opportunities for development of the irrigated horticultural sector in cooperation with Dutch companies.

For this purpose a mission to the target area was fielded in order to experience the local situation first hand and meet with relevant stakeholders. Additionally, available literature has been studied. The analyses of field experience and available information has been synthesized in this document, which gives a first insight in the actual situation, main constraints, challenges and needs of the irrigated horticultural sector in East Sudan as well as opportunities for development and cooperation with Dutch businesses.

The terms of reference for this horticulture study in East Sudan (K2K16SD51) is attached in Annex 1.

A mission report is elaborated that reflects the information collected during the interviews and site visits in Sudan, refer to Annex 9. The itinerary of the field trip in Sudan is given in Annex 2. Due to unexpected delay at Schiphol airport the mission started 1 day later than originally planned.

AgroFair-TASTE contracted for this study Mrs. Karin Bleijlevens, rural development expert of AgriNature, and Mr. Nico de Groot, horticultural expert of Delphy. The mission team for the field trip in Sudan consisted of Mrs. Bleijlevens and Mr. de Groot as well as Mr. Ali Abbas, economic official of the Royal Dutch Embassy in Khartoum, and Mr. Osman El Sheihk, regional farming expert and farmer.

2. Profile (East) Sudan

2.1 General

Sudan is the third largest country of Africa with an area of almost 1.88 million km^2. Sudan is 45 times larger than The Netherlands.

The country is administratively divided into 18 states which are grouped into 6 regions:

state	region		state	region
Khartoum	Khartoum		Blue Nile	Blue Nile
North Kordofan	Kordofan		El Gezira	
South Kordofan			White Nile	
West Kordofan			Sennar	
Northern	Northern		North Darfur	Darfur
Nile			South Darfur	
Kassala	Kassala		West Darfur	
Red Sea			Central Darfur	
Gedaref			East Darfur	

The capital is Khartoum, that forms jointly with Khartoum North and Omdurman at the west a metropolitan area with an estimated population of 5 million inhabitants. The entire country has an

estimated 36 million of inhabitants of which about two third is living in rural area. Other major cities in the country are Nyala (South Darfur), Port Sudan (Red Sea), Kassala, El Obeid (North Kordofan), Kosti (White Nile), Wad Medani (El Gezira) and Gedaref with an estimated population of each between respectively 550,000 and 340,000 inhabitants.

The main ethnic group is the Sudanese Arab (approximately 70%) which consists of descendants of migrants from the Arabian Peninsula like the Rashaida who are now living in Kassala State, as well as arabized ethnic groups of Nubians (along Nile in Sudan and Egypt as well as in New Halfa, Kassala), Copts (mainly Khartoum Region) and Beja nomads (Kassala Region). Other tribes are Fur (Darfur Region), Nuba (Nuba Mountains in South Kordofan) and Fallata (Gedaref). The national religion is Sunni Islam (97% of the population) next to Christianity (1.5%) and African traditional religions (1.5%). The national language is Sudanese Arabic and since 2005 also English. The legal system in Sudan is based on Islamic Sharia law.

Some general demographics of Sudan:

description	figure
Median age	19.6 years
Total fertility rate	3.7 children born/woman
Children <5 years underweight	33%
Life expectance	64.1 years
Population growth rate	1.7% annually
Urban population	34%
Rate of urbanization	2.5% annually
Literacy	76% (men 83%; women 69%)

(Source: www.indexmundi.com)

East Sudan comprises the states Red Sea, Kassala and Gedaref. These states share a number of historical, ethnic, social and political characteristics. They also share the experience of long standing marginalization, underdevelopment and chronic poverty.

Some general data regarding East Sudan:

Description	Red Sea State	Kassala State	Gedaref State
Area (km^2)	218,887	55,500	75,263
Total population	1,400,000	1,770,000	1,400,000
Capital	Port Sudan	Kassala	Gedaref
Population capital	520,000	420,000	340,000
Population in rural area	38%	74%	71%
Population classified as poor	58%	36%	50%
Tribes/Groups	Beja (65%)	Hadendoa-Beja Rashaida	Multicultural (migration)

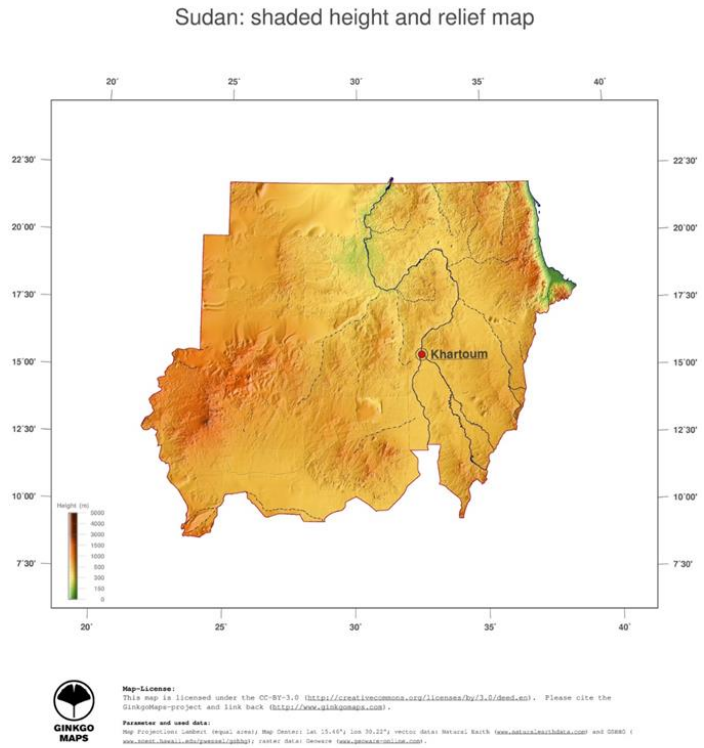
Sudan is at the centre of the Eastern African migration route towards North Africa and Europe. Through civil wars, political turmoil, repression and famines, about 367,000 refugees are residing in the country of whom some already for 30-40 years, so 2 to 3 generations. Additionally, about 3.1 million people are internally displaced, originating from Blue Nile, South Kordofan and Darfur which are instable regions that suffer from internal conflicts. East Sudan inhabits more than 100,000 refugees living in 6 refugee camps located in Kassala State and Gedaref State. Currently, refugees are coming predominantly from Eritrea (mainly Tigrinya, often Christians, of the highlands) and by far

less from Ethiopia, Somalia, Central African Republic and even from Northwest Nigeria. Also people from South Sudan are moving to East Sudan, although they are not officially recognized as refugees.

2.2 Agro-ecology

2.2.1 Topography

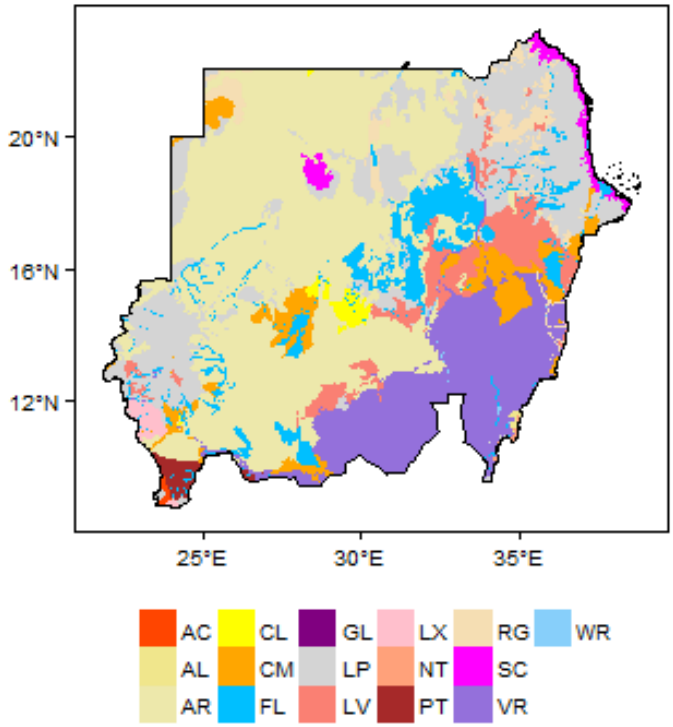
The topography of Sudan is a broad plain with mountains up to 2780m (Jebel Hamoyet) in the Northeast near the Red Sea coast and mountains up to 3025m (Jebel Marra) near the southwestern borders. The river Nile flows through the country from south to north. The White Nile, originating from Lake Victoria, and the Blue Nile, originating from the Western highlands of Ethiopia, confluences in the capital Khartoum. Another important tributary of the Nile is the river Atbara that originates from the Northern highlands of Ethiopia.



2.2.2 Soils

Sudan has a great variety of soils in its national territory. The main identified soils according the FAO Soil Classification System are: erosion susceptible arid Arenosols in the central and western part of the country; thin erosion susceptible Leptosols in the mountainous regions in the northeast and southwest; Vertisols with very heavy clay in the southeast; and in the central and eastern river delta's the fertile Fluviosols (young river sediments), Cambisols (relatively young, brown soils) and Luvisols (with clay layer). Close to the Red Sea coastline saline Solonchaks are identified.

Soil map of Sudan



(Source: European Commission Joint Research Centre: European Soil Portal)

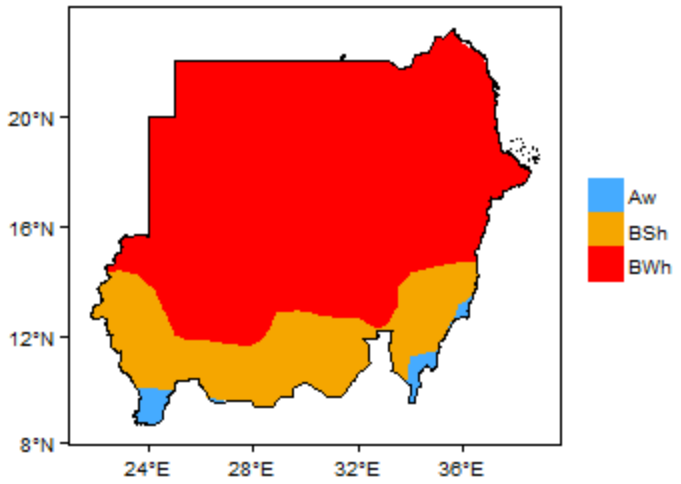
Acrisols	Calcisols	Gleysols	Lixisols	Regosols	Water body
Alisols	Cambisols	Leptosols	Nitisols	Solonchaks	
Arenosols	Fluvisols	Luvisols	Plinthosols	Vertisols	

2.2.3 Climate

The central and the northern part of Sudan are extremely dry and hot such as the Nubian Desert in the northeast and the Bayuda Desert in the centre. The amount of rainfall increases towards the south with swamps and forests in the extreme south. Sudan's rainy season occurs in summer and lasts for about three months (July to September) in the north, and up to six months (June to November) in the south. The Red Sea coastline has a different, opposite rainy season in winter, between November and January. In winter time humid and cool westward wind jets blow daily a humid breeze from the sea land inwards. Due to clouds, solar radiation is less at the coastline. However, in summer, hot, dry eastward wind jets blow from the desert through the Tokar Gap in the Red Sea Hills to the sea. The old town centre of Tokar is even designed according these prevailing wind jets with broad streets in Northeast-Southwest direction.

In general, dry regions are plagued by sandstorms, known as haboob, which can completely block out the sun. The sunshine duration is very high all over the country but especially in deserts where it could soar to over 4,000 hours per year. The average annual temperature is about 30°C but maximum temperatures can go up to 50°C in the desert.

Climate Map of Sudan



According the climate classification of Köppen-Geiger the following climates occur in Sudan:

Aw	Tropical wet and dry ***savanna climate*** with the driest month having precipitation less than 60mm and less than 4% of the total annual precipitation. This type of climate has every month of the year with an average temperature of 18°C or higher, with significant precipitation.
BSh	Hot semi-arid or ***steppe climate*** low-latitude climate with average annual temperature above 18 °C and little precipitation
BWh	Hot arid or ***desert climate*** low-latitude climate with average annual temperature above 18 °C with very little precipitation

More detailed figures about the climate in East Sudan are given in Annex 3.

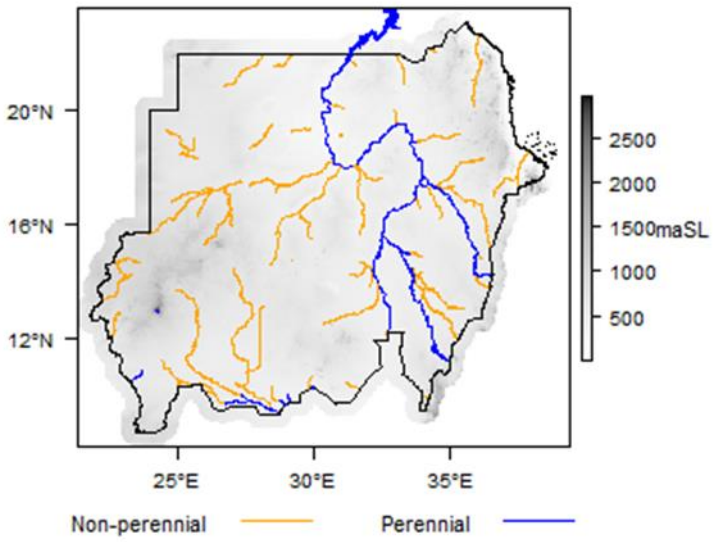
2.2.4 Hydrology

The major surface water resources of Sudan are mapped below. The Nile river and its main tributaries White Nile, Blue Nile and Atbara are broad, relatively shallow, perennial rivers. The annual capacity or discharge of these rivers is respectively 24 milliard m^3 annually, 50 milliard and 10 milliard, which makes a total of 84 milliard m^3 measured at the Aswan Dam, located near the border of Sudan and Egypt. In 1959 the Nile Agreement was signed between Sudan and Egypt, assigning to Sudan a total abstraction share of 20.55 milliard m^3 annually measured at the Sennar Dam of which currently 15 milliard m^3 is used.

Additionally, a lot of seasonal rivers occur during the rainy season in Sudan, normally called Khor or Wadi, like the Gash river close to Kassala town and the Baraka river near Tokar in Red Sea State. All these seasonal rivers account for an annual discharge of 6 to 10 milliard m^3.

All rivers, perennial and seasonal, flood their broad river banks during the rainy season, providing water as well as a fresh load of fertile soil that will sediment.

Map of major surface water features of Sudan



(Source: World Wildlife Fund HydroSHEDS; Digital Chart of the World drainage; FAO Inland Water Bodies)

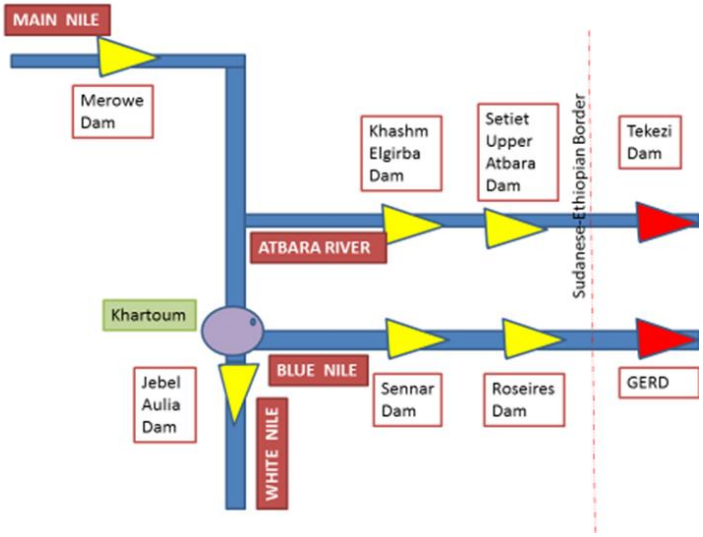
Besides rainfall and perennial and seasonal rivers, ground water is another water resource. It is estimated that in Sudan 563 milliard m^3 water is stored in subsoil water reservoirs or aquifers, which are annually recharged with about 5 milliard m^3. It is estimated that currently less than 1 milliard m^3 is abstracted annually.

In Annex 4 a hydrogeology map of Sudan shows a simplified overview of the type and productivity of the main aquifers at a national scale. The different types of aquifers are also shortly described, including the Gash Aquifer in Kassala as well as the situation in Gedaref and at the Red Sea coast.

2.2.5 Irrigation & water-harvesting

The main rivers Blue Nile, White Nile and Atbara provide currently about 15 milliard m^3 water for irrigation purposes; 5 milliard m^3 of the Sudanese share of the Nile still remains unused. Currently, a total area of approximately 1.68 million Ha is irrigated and the potential exist of 2.52 million Ha.

All three rivers have specific dams and schemes; see figure below. The largest irrigation scheme is Gezira (870,000 Ha), located West of the city Wad Medani, which is supplied by the Blue Nile (Sennar and Roseires dams). This irrigation scheme is one of the largest in the world. The Rahad irrigation scheme (121,500 Ha), located at the east bank of the Rahad river near Fau in Gedaref, is also supplied by the Blue Nile (Roseires dam) as well as the seasonal river Rahad. The New Halfa scheme (152,280 Ha) in East Sudan is supplied by the Atbara river through the Khashm el Girba dam. The scheme is located at the West bank of the river Atbara. Through the construction of the Setiet Upper Atbara Dam, a new irrigation scheme will be developed at the East bank of the river Atbara, connecting with the West bank of the seasonal river Gash near Kassala.



(Source: presentation Dr. Adil Mohamed Elkhidir, University of Khartoum)

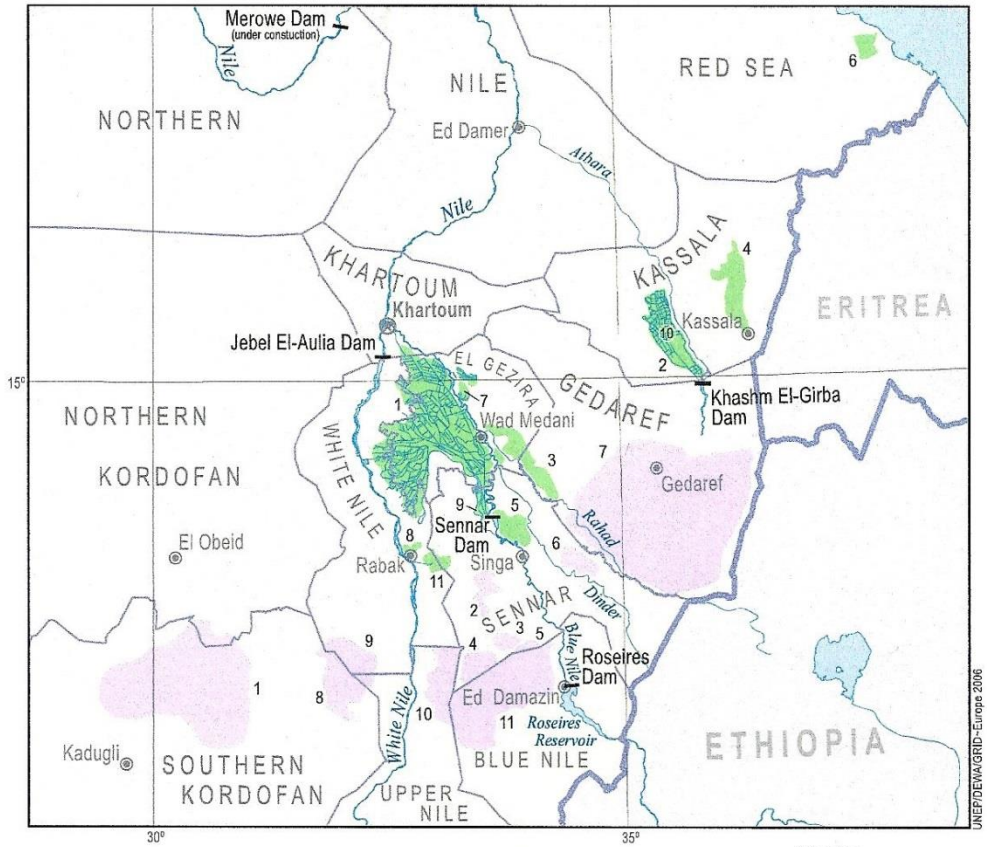
Besides permanent irrigation schemes supplied by perennial rivers, there are also irrigation schemes implemented supplied by seasonal rivers, called spate irrigation. These irrigation systems function on the temporary supply of water. Based on the water flow provided by the seasonal river no year round production can be realized. As the discharge flow varies also from year to year, it is not assured which area can be irrigated and when. Year-round production might be possible through the additional subtraction of groundwater by a water well.

There are a number of spate irrigation schemes in Sudan, like the Gash Delta in Kassala, supplied and located at the east bank of the seasonal Gash river, as well as the Tokar Delta in Red Sea State, supplied by the seasonal Baraka river. The Gash river flows normally from June to October. The Baraka river flows normally from October to February.

On the next page, a picture is shown including the location of existing irrigation schemes of Sudan.

All formal irrigation schemes are managed by state entities. All schemes have open, earth channels and lining is only applied around irrigation structures. The distribution of water within spate irrigation schemes is not regulated with structures. The water supply to the field is realized by surface irrigation or flooding into small basins, called Angaya system. Mechanization is difficult and no proper field drainage exists. Siltation is not a problem at field level where it provides a fertile layer, however it is a serious problem in the distribution channels, pump stations at intakes and reservoirs created by dams, resulting in decreased capacities or discharges as well as reduction of the effectively irrigated area.

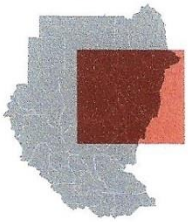
Farmers do not pay for their irrigation water consumption, but should pay a fee according to their acreage for maintenance. In practice this fee is often not collected or the amount is not enough. The maintenance of the schemes including dams and reservoirs depends mostly on international donor funds.



DRAFT VERSION

Kilometres
0 50 100 150 200 250
Lambert Azimuthal Equal-Area Projection

Sources:
SIM (Sudan Interagency Mapping); FAO; vmap1v0, gns, NIMA; The Gateway to Astronaut Photography of Earth, NASA; various reports, maps and atlases; UN Cartographic Section.



Irrigated Agricultural Schemes

1. Gezira and Managil	870'750 ha	7. Guneid Sugar	15'795 ha
2. New Halfa	152'280 ha	8. Assalaya Sugar	14'175 ha
3. Rahad	121'500 ha	9. Sennar Sugar	12'960 ha
4. Gash Delta	101'250 ha	10. Khashm El-Girba	18'225 ha
5. Suki	35'235 ha	11. Kenana Sugar	45'000 ha
6. Tokar Delta	30'780 ha		

Mechanized Agricultural Schemes
(planned and unplanned)

1. Habila
2. El-Dali
3. El-Mazmum
4. El-Raheed
5. El-Sharkia
6. Dinder
7. Gedaref
8. Southern Kordofan
9. White Nile
10. Upper Nile
11. Blue Nile

Agricultural schemes boundaries are approximate.

Another serious problem in irrigation schemes, especially in spate irrigation schemes like Gash and Tokar, is the presence of one of the most problematic invasive species, called Mesquite (Prosopis sp., mainly Juliflora and Chilensis). Mesquite is a small leguminous tree with pods with hundreds of seeds and profound roots. The specie has been introduced in the arid climates of Sudan to control wind erosion, to stabilize sand dunes and to serve as shelter belt and as fodder for livestock. Mesquite invades the irrigation channels and fields as it grows well in humid soils and survives well in arid soils. Eradication is problematic and costly.

In the table below, the original designed, currently used and potential area of spate irrigation in the Gash and Tokar schemes are given.

	Design (feddan)	Operational (feddan)	Rehabilitation (feddan)	Potential (feddan)
Gash Scheme	200,000	80,000	40,000	120,000
Tokar Scheme	400,000	120,000	45,000	165,000

(Source: presentation Dr. Adil Mohamed Elkhidir, University of Khartoum)

In general, it can be concluded that the functioning of irrigation schemes is often problematic and the efficiency is low. There are no incentives to introduce water saving technologies like drip-irrigation.

Additional to the formal permanent and spate irrigation schemes, farmers irrigate also through seasonal flooding of rivers and/or pumping-up of water directly from the river, if their fields are located at the river banks. Along the entire Nile river and its perennial tributaries small scale irrigation occurs. Alternatively, farmers subtract (additional) water from aquifers through water wells. All these systems have common that the water application to the field is realized through surface irrigation without proper drainage and no payment is charged for the direct use of water besides the costs of the well and/or water pump and its diesel; water itself is for free!

Besides irrigation water for agricultural production, water is also required for human consumption as well as for livestock.

Around the town of Kassala, an area of approximately 26,000 feddan (10,920 Ha) is cultivated outside the Gash spate irrigation scheme; the total available area for cultivation is about 56,000 feddan (23,520 Ha). Presently about 1800 farmers with small scale irrigation apply seasonal flooding of the Gash river as well as subtracting of groundwater that is recharged by the Gash river. As a consequence, the ground water table is dropping excessively and about 300 wells (12-70m depth) dried out.

The future increase of irrigated land for agriculture in Sudan, in general as well as in East Sudan, will be in water harvesting techniques. The Girgir project at the east Gash shore is a successful example. An earth dam spreads the water of a wadi or seasonal river downstream the dam with uncontrolled flooding for agricultural production. The construction of a dam to harvest water from the seasonal Rahad river in Gedaref is planned.

2.3 Agriculture

Agriculture in Sudan is very diverse. It is estimated that 18,630 km^2 is irrigated, 67,000 km^2 is used for rainfed agriculture and 240,000 km^2 is used as pasture land as well as for grazing by nomadic cattle farmers. Also huge areas of non-cultivated land are used for nomadic grazing of approximately 40 million cattle, 39 million sheep, 32 million goats and 4.7 million camels.

The main cash crops cultivated in Sudan under irrigation are: cotton, groundnuts (peanuts), sugarcane, sesame, vegetables and fruits as well as animal feed like alfalfa. Subsistence/food crops cultivated are: sorghum, millet, wheat, corn, barley and pulses like cowpeas and beans. In view of food security, sorghum is also cultivated under irrigation. Sesame, gum Arabic, cotton and hibiscus are the main export products as well as cattle. Since Saudi Arab prohibited the cultivation of fodder crops for its livestock due to water scarcity, irrigated alfalfa is grown in Sudan and exported as fodder for dairy cattle raised in Saudi Arabia.

Farming practices in Sudan can be typified as follow:

- Mechanized irrigation schemes
- Traditional irrigation
- Mechanized rain-fed agricultural schemes
- Traditional rain-fed agriculture
- Livestock husbandry / pastoralist

A map of livelihood zones in Sudan, referring to type of agriculture practiced, is shown on the next page.

In the northern and western semi-desert areas, people rely on the scant rainfall for basic agriculture and many are nomadic pastoralists travelling with their herds of cattle, sheep or camels.

The central organized permanent irrigation schemes like New Halfa and Rahad in East Sudan, are dedicated to the obligated rotated production of sorghum, cotton and/or groundnut by small farmers. The production and marketing of these crops are controlled by the Sudanese government due to reasons of food security in case of sorghum and export of cash crops in case of cotton and groundnut. In New Halfa also sugar cane is produced and processed by a state owned company. The cultivation of vegetables within these irrigation schemes is very limited, although in New Halfa the farmers own also a small irrigated plot that they can freely cultivate. Most farmers cultivate presently vegetables in these plots and are also interested in fruit trees like mango and citrus. These farmers of New Halfa are originally from the town Halfa at the east bank of the Nile river in the very North of Sudan, neighbouring Egypt. When the Aswan dam was constructed, Halfa was flooded by lake Nassar and the inhabitants of Halfa were resettled in the new irrigation scheme of New Halfa in Kassala State which was constructed for this purpose. The settlers/farmers of New Halfa were from the beginning involved in the development and operation of the New Halfa irrigation scheme, resulting in the fact that this irrigation scheme is by far the best managed scheme in Sudan.

In the central, state organized spate irrigation schemes like Tokar and Gash Delta in East Sudan, farmers are obligated to produce sorghum and cotton. The production of vegetables within the Tokar irrigation scheme is formally limited to 10% of the area, but in practice a larger area is grown with vegetables as it offers to farmers more profit.

Outside the Tokar and Gash irrigation schemes and along the river banks of the Nile, White Nile, Blue Nile, Atbara and Rahad, farmers grow cash crops like vegetables and fruits, applying small scale irrigation like river flooding and water wells.

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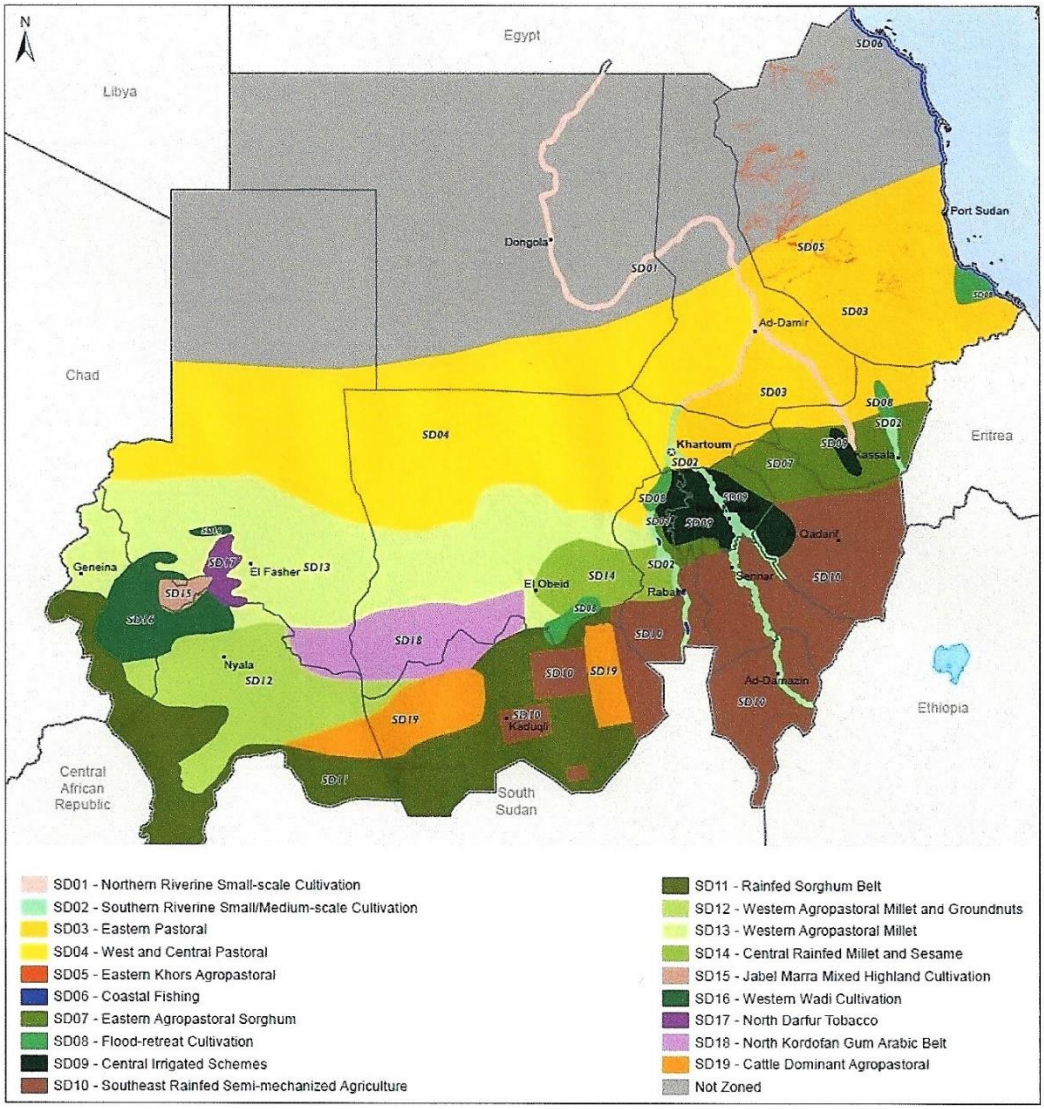
SUDAN

Rural Livelihood Profiles for Eastern, Central, and Northern Sudan

January 2015

MAP OF LIVELIHOOD ZONES IN SUDAN



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In the rainfed areas of Gedaref, mechanized sorghum is cultivated. In the water harvesting project of Girgir in Kassala, also sorghum is cultivated.

The general observation is that there is no lack of arable land or absolute water scarcity in Sudan, but the challenge is to improve water efficiency, yields and profits.

Unfortunately, agricultural expansion has proceeded without conservation measures. The consequences are manifested in the form of deforestation, soil desiccation, declining soil fertility and lowering of the groundwater table. Desertification is a serious problem and there is also concern over soil erosion. In Kassala, farmers experience that the rainy season as well as winter period are shortening.

2.4 Infrastructure

Energy is generated by the dams in the river Nile and its perennial tributaries. There are 6 hydropower stations of which the Merowe Dam in the northwest of Sudan, the largest is with a capacity of 1,250 MW; the total country production is 2,400 MW. The Merowe Dam supplies most of the electricity to Khartoum.

Sudan has about 12,000 km roadways of which about 4,500 km is paved. The major cities are well connected with asphalt roads in a good condition. Often next to the major roads, railways of narrow gauge are located. Despite the 5,800 km railways, only a few tracks are still operational, mainly for cargo, like the track from Khartoum via Atbara to Port Sudan.

The country has 74 airports, of which 2 are formally international airports, Khartoum and Port Sudan. The later, however, operates very limited international flights (Jeddah and Cairo). For cargo, there is a short-term storage facility at the airport of Khartoum of which a limited part is cooled.

The main sea harbour is located in Port Sudan. In order to connect to worldwide destinations, cargo has to be transhipped in Jeddah, from where the international shipping lines operate. A few companies offer mobile cold chain services and storage.

Along fixed telephone lines, there are various providers of mobile telephone communication, covering the entire country. Approximately 77% of the inhabitants of Sudan use mobile telephones, 22% has access to internet and only 0.3% has a fixed telephone line.

2.5 Investment & business climate

Sudan is a lower middle income country with a Gross National Income of USD 1840 per capita. The country's economy has suffered from the secession of South Sudan in 2011 and the loss of oil revenues. The economy, however, is recovering driven by agriculture and mining industry (gold).

The agriculture sector contributed in 2015 for 34.5% to Sudan's Gross Domestic Product. The growth of GDP was quite stable over the recent past years and is expected to be sustained by the revitalization of the agricultural sector and the increased production and export of minerals in combination with restraining inflation. Inflation was the highest in Africa due to exchange-rate devaluations and civil conflicts. Tight policy has let drop inflation considerably over the recent past years.

	2013	2014	2015	2016
Growth of GDP	3.6%	3.4%	3.1%	3.7%
Inflation	36.1%	37.7%	21.8%	21.3%

(Source: Economic Outlook 2015)

A major downside risk for economic recovery, however, is the growing deficit of foreign exchange. Due to foreign exchange shortages and limited exchange rate flexibility, a considerable gap exists between the official and parallel-market exchange rates. The official rate by February 2017 was EUR 1 to SDG 6.9 and the market rate EUR 1 to SDG 17.5.

Since 2014, foreign correspondent banks refuse to process transfers to and from Sudan in order to avoid violating US sanctions that have tightened the foreign-exchange market and raised the costs of imported inputs. The US sanctions, however, are removed since 13 January 2017, and transfers between foreign banks, including US banks, and the Central Bank of Sudan are these days starting-up. The local business community feels relieved. Although it still takes to mid-2017 before all sanctions are formally lifted.

The revitalization of the agriculture sector in combination with the allowance of the Central Bank of Sudan that exporters can sell their products to importers, has boosted the export of traditional agricultural cash crops like gum Arabic and sesame. The import of agricultural inputs and technology is free of levies.

According to the World Bank Doing Business report 2017, Sudan ranks 168 of 190 countries with respect to overall performance. In the corruption perceptions index 2016 of Transparency International, Sudan ranks 170 of 176 countries.

3. Horticulture in (East) Sudan

Many types of fruits and vegetables can be produced in Sudan and almost year round due to climatic variations and the availability of water. Fruits and vegetables are mostly cultivated with small scale irrigation, but also rain-fed in the southern states in areas with high rainfall. Vegetables are to a limited extent also grown within permanent irrigation schemes.

The economic impact of fruits and vegetables is, however still very limited compared to the actual production potential. This is due to less attention paid to vegetables and fruits compared to cash crops like cotton, peanut, gum Arabic and staple food grains like sorghum. It is even difficult to obtain reliable data on the area and production of fruits and vegetables.

Market in Khartoum

3.1 Crop range & seasonality

A broad range of horticulture crops can be cultivated in Sudan, classified according the Ministry of Agriculture:

Fruits	mango, lime, grapefruit, banana, guava, dates, orange and mandarin
Vegetables	onion, tomato, potato, melons, watermelon, zucchini, pumpkin, snake cucumber (gourd), eggplant, okra, radish, green beans, green peas, carrots, beets, dill, jew's mallow, cucumber, sweet potato, purslane, arugula, chili peppers, sweet pepper and even cabbage and broccoli
Herbal & aromatic plants	garlic, fennel, hibiscus, henna, tamarind, baobab, desert dates, mint, fenugreek, lemon grass, etc.
Legumes	broad beans, cannellini beans, lentils, chickpea and yellow split peas.

In Annex 5, the range of locally available horticultural crops is given related to the calendar of import allowances. Almost all crops are locally produced, although some in a very limited quantity compared

to the demand and others are only seasonally available. Those crops that cannot meet local demand, are permitted to import periodically.

The most important horticultural crops with their supply or marketing season as well as their major production locations are given in the table below.

Crop	Location (State)	High season (months)	Off-season (months)
Fruits			
Mango	Western Darfur, Southern Kordofan, Northern, Khartoum	January-September	October-December
Banana	Kassala (35%), Blue Nile (25%), Gezira, Sennar, Khartoum	-	-
Grapefruit	Northern (60%)	August-October	November-July
Orange	Northern (40%), River Nile, Western Darfur	September-March	April-August
Lemon/lime		April-June	July-March
Dates	Northern, River Nile	June-March (fresh)	April-May
Vegetables			
Onion	Kassala, Gezira, Blue Nile, Khartoum	November-April	May-October
Tomato	Kassala, Gezira, Blue Nile, Khartoum, Red Sea (Tokar)	October-March	April-September
Melon		January-April	May-December
Watermelon	Red Sea (Tokar)	November-March	April-October
Potato	Northern, Khartoum	March-June	July-February
Okra		December-February	March-November

In Kassala, the peak production season of tomatoes is during the rainy season when the Gash river floods (June-October): sowing in July and harvesting in October. The second main season is during the winter, using well-irrigation: sowing in November and harvesting in February. A third season during summer (March-June) is possible, using heat-resistant seeds and well-irrigation. In practice, this additional third season is not applied due to high costs and risks. Similar patterns are valid for other vegetables grown in East Sudan with exception of the Red Sea coastline. In New Halfa and Rahad, where permanent irrigation is available, three crop cycles can be grown annually. However, during summer more expensive heat-resistant seeds should be applied, because of the high temperatures during day time.

At the Red Sea coast, like in Tokar, the rainy season occurs in winter, from November to January, and the Baraka river floods from October to February. So the peak production season for vegetables runs from November (sowing) to February (harvesting). However, with well-irrigation a second production season occurs from March to June that fits the off-season in the national market (excluding Port Sudan), fetching higher prices.

In general selling prices of vegetables as well as fruits fluctuate greatly during the season, referring to their high supply season and off-season. At the beginning of harvest time, there is a surplus of supply and prices go down to the extent that earned revenues do not cover the cost of production. During the off-season or low supply season, sales prices increase strongly due to a shortage in production as well as due to the higher costs of farming during the hot summer (hybrid seeds, well-irrigation). Especially for vegetables it is interesting to target the Ramadan period as the demand for fresh products is very high in this period, so better prices can be fetched.

3.2 Production figures

Both, production and consumption of fresh fruits and vegetables are increasing in Sudan due to increased urbanization, awareness of their nutritive value and relatively high returns. The increase in horticultural production, however, is rather horizontal; the production area increases, but productivity remains low as there is only little increase in yields. This indicates that there is a high potential for improvement.

In Annex 6 the area and annual production figures as collected by the Ministry of Agriculture are shown for a range of vegetables and fruits. Additionally the average annual yield has been calculated as well as the annual growth. It is clear that the production of vegetables and fruits continuously has been growing, especially in favour of fruits. Onion is by far the largest cultivated crop, followed by mango, banana and tomatoes.

Fresh vegetables are locally marketed and consumed or in other urbanized areas in the country, like greater Khartoum, Wad Medani and Port Sudan.

Arround Kassala town, an area of approximately 40,000 feddans (16,800 Ha) is dedicated to the production of fruits and vegetables of which 6,000 feddans (2,520 Ha) dedicated to the production of tomatoes. Horticulture is cultivated on land ranging in size from 5 up to 300 feddans (2.1 - 126 Ha) from small to large farmers.

3.3 Post-harvest handling & processing

Generally, huge losses occur in horticultural crops due to poor harvest and post-harvest practices as well as the lack of processing facilities to absorb the surplus production. Losses are estimated 30 to 40%.

In order to extend the marketing season for vegetables and fruits, cool or conditioned storage has to be introduced. Currently there exist no cooled storage facilities in East Sudan.

Tomatoes can be processed to tomato paste. Various vegetables can be (sun-)dried like onion, okra, tomato and chili peppers, even fruits like mango, citrus and banana can be (sun-)dried. Some small-scale processing, at household level, has been adopted by women, drying tomatoes and pasting them. In Kassala onion drying has been practiced shortly, but there is a lack of demand for dried onion flakes. Also tomato processing facilities have been established in the past in Tokar and Kassala, funded by international donors, but both facilities are not (anymore) operating. One reason of failure might be the fact that the tomato varieties grown are primordially for fresh consumption and less suitable for processing to juice or concentrate.

Large-scale processing exists only in Khartoum area, were tomato pastes are canned and fruit juices and marmalades are prepared and packed from cheap, imported concentrates.

In 2013, a new company has been established in Khartoum, dedicated to the post-harvest handling (washing, sorting, sterilization), packing and export of fruits and vegetables according GlobalGap standards. Recently, this company announced the establishment of a new packing plant in Sennar State, which will merely be dedicated to bananas.

3.4 Import & export

The main fresh fruits and vegetables that are imported are fruits like strawberries, apples, pears, grapes, cherries and kiwis from countries like Egypt, Lebanon, Qatar and China. Additionally, processed fruits and vegetables like tomato and fruit concentrates are imported for the canning of tomato paste and bottling of fruit juices for sale to the Sudanese retail market.

The export of fruits and vegetables is very limited and considers mainly melons, mango, banana and onion. Close to the borders exists some informal exchange trade with neighbouring communities as occurs with potatoes from Eritrea.

As most Sudanese vegetables are produced in winter, from November to March, export would fit very well to fill the seasonal gap demand in Europe. In areas with irrigation, it is possible to grow vegetables year-round.

4. Critical factors for development of the horticultural sector in East Sudan

During the field mission from February 3rd till February 14th a number of critical factors for the development of the horticultural sector in East-Sudan have been identified. The factors relate to a range of issues along the whole supply chain. In this chapter each of the factors will be discussed and analysed.

4.1 A fragmented production structure

The way fruits & vegetables are being grown in East-Sudan is in many cases characterized by a rather fragmented production structure. It means that commonly quite some actors are involved:

- the land owner (either a private person or the local community),
- the actual grower (leasing the land),
- a third party investor providing capital for essential inputs as seeds or fertilizers
- and many times a trader who organizes the harvest (hiring of women to harvest and men to pack and load), packaging and transportation to the market.

The actual grower in majority has an immigrant background being from the north or west of Sudan or even from West-African countries like Nigeria. Hired labourers commonly are refugees/displaced persons from southern Sudan, Ethiopia or Eritrea.

A range of different share cropping arrangements exist in which expenditures and yields are shared between the landowner, actual grower and third party investor. In many cases the work on the land and the irrigation is done by the grower while the land owner and/or 3rd party investor provides capital for purchase of seeds or fertilizers (and sometimes pesticides).

The fragmented production system results in production practices with a short term focus and with limited to no attention to long term soil fertility, erosion reducing practices, eradication of mesquite or proper maintenance of the irrigation channels.

In case the grower is not involved in the harvesting and sales, the motivation to produce a quality product will be lower while also the connection to the market is missing. Without the linkage to the market and the seasonality of the production, most growers will receive often prices just enough to cover costs and survive, but not enough to save and invest. With limited or no working capital available, the chance that farmers will start using more expensive, but more productive and efficient technology and inputs like improved varieties/seeds, will be small.

The fragmented production structure complicates also the organization of growers into sales and marketing groups/associations. It also raises the question whom to target in a project/intervention.

Picture: Small farmer/share cropping onion harvest, Kassala

4.2 Access to water

Horticultural production similar to all agricultural practices in the East Sudan region is limited by the access to water. Horticulture is pre-dominantly practiced in those areas were either permanent irrigation is possible (New Halfa Scheme) or in those areas where seasonal river flooding or spate irrigation (Tokar and Gash Delta) can be complemented with water from wells. In southern Kassala and Gedaref also rain-fed vegetable growing is practiced to some extent.

The common system of irrigation is surface irrigation which is simple and low cost but at the same time not efficient and far from optimal from the agronomic point of view. As the pressure on water resources is increasing due to population growth (both natural growth and inflow of refugees) and ground water levels are decreasing (up to 1 m annually in Kassala), a growing need is present to optimize the use of water for horticulture practices. However, the use of water itself is free of charge and therefore no incentive is present to invest in water saving technology.

Irrigation schemes show also problems with maintenance as users seem to have no ownership to the system. Maintenance fees are often not paid.

Picture: Gedaref Rahad irrigation channel

4.3 Market access

Many growers are not involved in the sale of their produce or even in the harvest. The common practice still exists that traders buy the crops of the field and take harvesting, packaging, transportation and trading in their hands. Most growers have therefore no idea about the demand in the market: what are prices, which products are requested by consumers, what are quality standards, how should a product be presented? For individual growers market access is difficult as the (middlemen) traders control the market and block entering the market of individual growers either physically or price wise.

Direct access to markets for growers (those who actually produce the fruits & vegetables) will be crucial to get a larger "piece of pie" into the hands of growers enabling them to save some money for working capital and means to invest. For this reason growers need to organize themselves into associations/cooperatives in order to get access to and a better bargaining position towards purchasers.

Whole sale markets as an organized place for trading of fruits & vegetables with certain rules and standards for hygiene and quality, post-harvest handling facilities (sorting, packaging, conditioned storage) and quality control are non-existent in Sudan. The development of such organized market places combined with organized supplies of products by growers (through cooperatives or associations) while be crucial for development of the horticultural sector in the country.

Picture: Khartoum retail sale market

Access to market information for growers is another point of attention. As the majority of growers are not involved in selling the produce themselves they have very limited understanding about the way the market works: when are prices high/low, what are niche products, when do products from other parts of the country come to main markets like Khartoum? Prices of fruits & vegetables seem to fluctuate on a day-to-day or week-to-week basis.

In Kenya a mobile based information system has been developed providing subscribers to get day-to-day information on wholesale and retail prices of a range of fruits & vegetables on the main markets (MFarm: www.mfarm.co.ke). Apart from providing market information MFarm operates a platform at which sellers can offer their products and buyers can link-up with the suppliers. Also crop information is available on the website. A similar system can be developed in Sudan.

Products in Sudan are offered in many different sizes, weights and packaging. Standardization of the sales quantities and packaging will be helpful to collect and compare market prices and create some transparency on the market.

Picture: Products new Halfa market.

4.4 Post-harvest handling facilities and logistic infra-structure

Storage and post-harvest handling facilities are almost absent in East Sudan. In combination with the prevailing hot climate conditions, the lack of storage capacity and post-harvest handling contributes to the imbalances and price volatility on the markets. The existence of conditioned storage facilities will allow a larger sales window and therefor providing the opportunity to collect higher prices for a part of the produce.

Storage and handling facilities with proper hygiene rules and packaging standards are essential for developing any export potential. As such, facilities require substantial capital investments, so joint activities of growers will be required (in cooperatives or associations) with support of the government.

A similar picture exists for conditioned transport of products to the main markets like Khartoum. A market opportunity exists to supply the Khartoum market with tomatoes from Tokar in the off-season (April-September). However this can only be done with cooled trucks in proper packaging (smaller boxes) to keep up the quality and shelf life. Such activity normally will exceed the capacity of individual growers and therefore asks for joint organization of the growers.

During the field mission it became clear that transportation of goods is subjected to all kind of levies and taxes. Such taxes and levies are a major source of income for state governments. Though insight in the actual level of these levies and taxes is lacking, the impression exists that they can go up as high as 15-20% of the product value. At the end, these indirect taxes will result in lower prices for the growers.

4.5 Processing facilities

Throughout the region of East Sudan no processing of fruits and vegetables is operational. Processing of fruits & vegetables seems to be concentrated in and around the capital of Khartoum. The bulk of products processed is of foreign origin (imported!!). Sourcing of locally produced products is said to

be more difficult and costly. By importing concentrates, the company just buys what is needed in terms of quantity and quality for a price as low as possible.

At the same time, due to seasonality of the rainfall and subsequent flooding most of the produce comes at peaks in the market. The existence of local processing facilities will allow to add (some) value to the surplus production.

In the past initiatives have been undertaken by donor funded projects to establish local processing like the EU sponsored tomato paste factory in Tokar and the Dutch financed juice plant in Kassala. However, so far none of these initiatives proofed to be successful as they have not been based on a business approach involving the local business community/local producers. During the mission interest of local farmers/local business community was detected to invest in such ventures. A proper business plan and training will be preconditions for the future success.

Picture: EU financed tomato plant out of production, Tokar.

4.6 Access to and need for inputs

Higher production per m² with efficient uses of inputs will be the motor for any future development of the horticultural sector. Access to high yielding varieties adapted to the local climate conditions (temperatures up to 50°C and long dry spells) are a key element.

The regular flooding and high levels of silt in the irrigation water by nature, provide the basic level of fertilizers. Soil conditions in the region in general are good to very good for horticulture. At the same time specific nutrients can be in shortage causing low production and/or lower product quality. This in particular applies for potassium, magnesium and sometimes micro-elements like iron and boron.

During the mission it became clear that most commonly used fertilizers are available at local dealers. Composite fertilizers (NPK) are expensive and therefore should be used only when needed. At the same time growers apply cheap fertilizers like DAP and urea which are not always required. Simple but effective methods exist to analyse the soil and provide growers at low costs essential information on the nutrient needs of their soil (http://www.soilcares.com/en/products/lab-in-the-box/).

Pesticides are expensive and should be used with care in order not to harm the user, consumer and the environment. A range of pesticides is available at local dealers in major towns like Kassala, however the quality and effectiveness is hard to determine. Biological methods to prevent outbreaks

of pests & diseases (including resistant varieties and healthy plant material) as well as application of biological control products can be a suitable alternative to the use of pesticides. Biological control products seem not to be available in Sudan.

Picture: Seed cans and fertilizer bags in shop, Kassala.

4.7 Practical agronomical knowledge

Growers, in general, know themselves very well how to act upon the local climate conditions and mitigate risks for crop failure. Under the existing conditions in East Sudan this commonly results in low input-minimal risk-low output strategies. The usage of own propagated seeds or plants prevails while the application of fertilizer and pesticides are put to a minimum.

Most of the way of working is based on traditional knowledge or the practices of a neighbour. Information and experience with other ways of growing and new technologies is missing or is only present by those who have a direct commercial interest.

The general notice is that many growers lack essential, practical knowledge on agronomic issues. This knowledge includes soil preparation, nutrient needs and fertilizers, recognition and prevention of pest & diseases, planting systems and planting depths, crop maintenance and pruning, harvest and handling techniques to prevent damages to the produce. Existing local knowledge can be extended with knowledge on proper soil preparation, right sowing moment, effective re-use of crop wastes (composting), improved soil structure (by adding compost), proper own propagation of seeds and seedlings, right amount of seeds per m² and proper seed depth, proper crop rotation/mixed cropping systems, agro-forestry, pruning and rejuvenation of old orchards and safe, effective and efficient application of pesticides with a backpack sprayer or small mobile unit.

Though not investigated, it seems likely that the existing extension services run at state level, are not able to address these mostly, practical issues as the majority of the extension workers have no practical experience themselves or direct access to relevant information. From the side of suppliers of inputs, rather selective information towards the purchase of their products can be expected. Donor funded programs tend to have a short-term focus and in the majority of cases miss the agronomical knowledge themselves.

5. SWOT analysis horticulture East Sudan

Taking into account the findings of the mission and the information reviewed a SWOT analysis for the horticultural sector in East Sudan has been composed.

Strengths	**Weaknesses**
• Internal market of 36 million consumers with a growing demand for fresh fruits & vegetables in particular greater Khartoum area • Favourable location towards potential export market e.g. Arab peninsula • Availability of land with fertile soils • Presence of water • Warm climate allowing for multiple harvests during 1 year • Warm climate and low humidity levels reducing the need to spray against fungal diseases	• Limited availability of productive and locally adapted (commercial) varieties • Lack of linkage to markets by growers • Fragmented production structure • No cooperation/organization among growers • Lack of organized market structures (market associations of growers or whole sale market structures) • Lack of production planning e.g. strong fluctuation in prices • Low level of agronomic knowledge (soil, fertilizer, crop protection, crop management) • Low efficiency in water usage • Lack of local food processing • Lack of post-harvest handling facilities • Low productivity • Low quality especially in terms of product appearance • Climate too hot for optimal production of crops (high max. temperatures)
Opportunities	**Threats**
• Production in the off- season (especially for Khartoum market) • Production of crops which are imported during parts of the year e.g. carrots • Improved efficiency in crop production • Investment in post-harvest handling • Investment in processing of fruit & vegetables • Export to Arabic peninsula • Export to niche markets in EU e.g. organic products (sweet potato, banana, melon) • Direct sales of fresh products to end consumers in urban areas	• Decline and irregular rainfall • Aquifer depletion • Indirect taxation of horticultural production • International sanctions • Non-facilitating government policy e.g. towards the import of 2nd hand production technology, modern varieties, biological pesticides • Corruption • Competition from other regions/import in particular Egypt.

The overall conditions show a good potential for development of the horticultural sector in East Sudan. There is a local market especially in the fast expending metropole of Khartoum with a growing demand for fruits and vegetables. Price levels of vegetables and fruits are rather high especially in the off-season allowing to earn margins when the productivity and quality of production can be increased.

With a climate that allows multiple harvests during 1 year good export opportunities can be realised if certain quality and quantities can be arranged. This will require a supportive and facilitating role of the government (quality standards, export procedures, logistic infrastructure, taxation) while growers need to organize themselves in associations/cooperatives that will handle the export process on their behalf. Joint investments in post-harvest handling and logistics will be required.

The current low level usage of chemical fertilizers and pesticides in combination with specific climate conditions (low humidity) and fertile soils, provide good opportunities for the development of organic supply chains including export to the European market (sweet potato, banana, citrus, melon, onion, garlic).

The prevailing seasonality of the production of many fruits & vegetables offers the potential for local processing of the market surplus providing chances for additional income for growers.

6. Opportunities for development of the horticultural sector in East Sudan

Several opportunities for development of the horticultural sector have been identified. In this chapter these opportunities are presented into more detail. The chances for Dutch business will be highlighted in a separate paragraph.

6.1 Ideas for business development and employment creation

6.1.1 Joint producer initiatives to link market demand to production

Currently the majority of producers of fruits and vegetables depend on traders/middlemen to sell their products. Few producers seem to be active in the sales of his/her own product and therefore the majority has no direct link to the demands in the market.

Direct access of growers to consumers/retail will result in "a larger part of the pie" earned along the supply chain under control of the producers, and therefore resulting in higher margins. Another advantage will be that growers will better understand the demands of the buyers of their products in terms of quality, appearance and moment of delivery.

Such initiatives will demand joint activities of growers and the formation of market associations or cooperatives. This can be along the lines of the government incentives to stimulate farmers to form productive cooperatives

Initiatives can range from:

- joint supply of one or several products through own organized transportation to the market place (Khartoum market places or retail chains),
- joint planning of the production (which grower/member of the association will produce which quantity of product),
- joint collection, sorting, packaging and storage of one or several products (for example a packing station for banana in Kassala),
- organization of farmers' markets in major urban centres like Khartoum or Port Sudan: a place separate from existing market places where only producers will be allowed to sell their own products to the clients/consumers,
- Creation of platforms for direct sale to consumers/retail in urban areas using internet and mobile phones. These initiatives can involve home delivery and be based on freshness and healthiness (low or no pesticides use!).

Such initiatives will need the active involvement and mobilization of producers. They should realize that only by joint action they can have a larger influence on the sales as well as prices of their products. Suitable models of joint action from other parts of the country and neighbouring countries (Eastern Africa) can be used. The preparation of a business plan for the joint initiative is crucial: the business plan will make clear what investments will be needed, which steps will be followed, who will be responsible, what will be the costs, what will be the revenues and how these will be shared. As the joint initiative will involve real business, it will also result to the creation of permanent jobs and seasonal labour (post-harvest handling, transportation, sales).

From discussions during the mission, New Halfa is identified as a possible suitable location to support producers to undertake joint sales activities. Tokar Delta can be another area to introduce joint marketing initiatives.

The joint initiative can become the platform for the introduction of quality standards and certification for GlobalGAP and organic (as a group).

In the future the joint market initiatives can start exporting products to high potential nearby export markets on the Arab peninsula. Possibly export to EU in some cases can even be an option in the longer term in particular when quality standards, hygiene demands and certification has been put in place.

6.1.2 Local processing of surplus production of vegetable and fruits

The horticultural production has a strong seasonal character induced by the seasonality of the rain fall and subsequent flooding in areas like Gash and Tokar Delta as growers only start planting crops after the rains have started and their land has been flooded. Several months later the local and regional markets are flooded by products. As a result prices during this periods are low and growers will find it hard to sell their produce to the traders/middlemen who commonly will exploit the situation to their benefit.

Processing of the surplus production can be a way to take out a major part of the surplus production and therefore contribute to higher prices on the market for the remaining fresh produce. At the same time value is added to a part of the harvest which otherwise would be turned to waste.

Looking to the current state of the regional economy and local investment capacity food processing should be at costs as low as possible.

Drying of fruits and vegetables can be such low cost solution. Drying can include major vegetable crops like okra, onion, tomato, chilli pepper, herbs as well as citrus parts and banana. A business plan should form the basis for the investment in and the establishment of a dried fruits & vegetable processing unit. During discussions in Kassala local growers stated the interest to (co)-invest in such initiatives.

Though much more capital demanding, the development of a local juice processing unit is another opportunity which seems to have potential for development in Kassala region. As an example the Dutch juice business in Ethiopia, Africa Juice, (www.africajuice.com) can be taken. Crucial is that from the beginning a business approach should be taken involving the local community and local investors. The option for organic juice should be investigated.

6.1.3 Development of high potential single crop supply chains

From a first scan and impression during the field mission several crops have a potential to develop to cash crop. Further investigation will be needed to define which crop has the highest potential and what are the interventions needed to realise this potential.

The identified crops are:

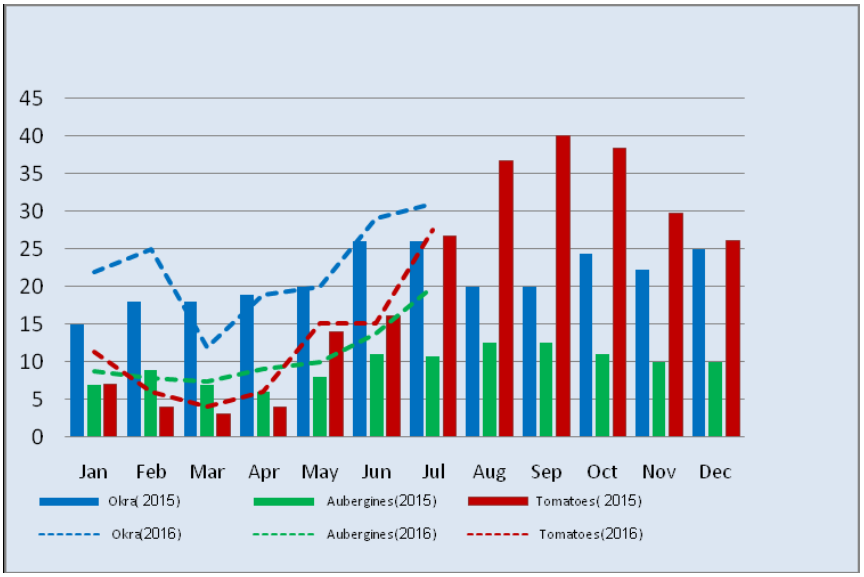
- *Onion*
  Climate conditions allow for the production of high quality onion at a competitive level in

particular for export to neighbouring countries like Eritrea, Ethiopia, South Sudan, Chad, Libya. Introduction of new, productive and heat resistant varieties (Bejo, De Groot 7 Slot, Hoza-Zaden, Enza), good agricultural practices and cheap options for storage of onion (3-4 months) will be required to increase the competitiveness of the existing onion production. A joint initiative of growers to form an "onion board" can be very instrumental to promote the onion production and export by introducing uniform standards for product quality, packaging and transportation.

- *Carrot*
  During part of the year carrots are being imported in Sudan while throughout the year a good demand for carrot seems to exists. It should be investigated how this local market demand can be met by applying the right agronomic measures. Preferably a group of growers should be involved. Dutch seed companies like Bejo, Nickerson Zwaan (Hazera), Nunhem and Kees Broersen Seeds (KBZ) can provide new varieties to be tested.

- *Tomato, sweet pepper and eggplant*
  Due to different rainfall patterns in Red Sea State production in Tokar follows a different time table than in other parts of the country. This allows Tokar growers to produce high value vegetable crops like tomato, eggplant and sweet pepper during the "off season" when prices are much higher. Tapping into this market opportunity will require joint sales activities of producers including joint transportation of the product to the Khartoum market. Introduction of new, heat resistant varieties should be supported with introduction of good agricultural practices (training and instruction).

Figure of main vegetable prices in Red Sea State 2015



(Source: Red Sea State Food Security Technical Secretariat)

- *Sweet potato*
  Local climate conditions suit very well the growing of sweet potato. In the EU there is a growing demand for sweet potato. Companies like Agrofair are investigating the option for

organic sweet potato on the EU market. Organic sweet potato can be grown well in East Sudan. In order to tap this potential the current practices should be investigated including an evaluation of the suitability of the current local varieties for export. New varieties and adapted production practices including curing and conditioned storage need to be introduced as well as other requirements to create a supply chain ready for export.

- *Galia melons*
  Production of Galia melons for export to Europe and Arab states started in Sudan in the 1980's. Production increased during the 1990's up to 1000 feddan (400 ha) (reference to article of Mr. Abd El Moniem Elyas El Houssien). The bulk of seeds were provided by Enza Zaden. Currently production of Galia melons seems to have declined and export has come to a hold. Rejuvenation of the export of Galia melons seems to be a very interesting opportunity for investigation however currently a ban on import of melons seeds will jeopardise such idea as it will prevent access to modern varieties that are demanded by the export market.

6.1.4 Related initiatives for development of the horticultural sector

- *Facilitation of practical training and demonstration*

One of the challenges for fruit & vegetable growers in East Sudan is to increase productivity in a sustainable way; more production per m² without depletion of the soil and water resources. Improved practical knowledge about soil, water use, fertilizers, crop protection and crop management will be crucial to realise this challenge.

Within each future project/business initiative a component of practical training and knowledge transfer combined with on-farm field demonstrations needs to be incorporated. The present NSAL potato project is an good example of combining training and practical knowledge transfer.

A need for long-term embedding of practical training and knowledge transfer combined with on-farm demonstrations exists. For instance till now this is not secured in the NSAL potato project. The impression arises that the current state organised extension services and agricultural research are not able to perform this task because of either a lack of capacity, finance and/or experience. In general the state extension workers are quite well educated, however lack the practical experience of modern, sustainable crop practices (Good Agricultural Practices).

In order to prevent each donor funded project making its own arrangements, it should be investigated whether at state level a practical training and demonstration centre can be facilitated. Such an organization should serve the interests of the farming community and therefore should be linked as close as possible to farmer associations and farmer representatives. In Kassala State the focus of such a centre could be on (well) irrigated horticulture while in Gedaref State the focus can be on rain-fed horticulture and agroforestry.

As much as possible private business should be involved in/linked to this centre through testing of new technology and contributing to the training program. From the beginning trainees should pay small fees for training and advice. A partnership with similar commercially oriented horticulture-knowledge companies like Delphy can be considered.

- *Water saving technologies*

More efficient use of water will be of crucial importance for the future sustainable development of the horticultural sector in East Sudan. A program for the introduction and demonstration of high efficient irrigation and agronomic practices as well as energy efficient irrigation technologies should be investigated. It concerns water harvesting practices, water storage solutions, drip-irrigation, solar pumps and application of flexible pipes/hoses instead of handmade channels.

As a first stage, an inventory of existing practise and available technology should be made combined with the inventory of private companies who have a commercial interest to sell the technology in Sudan. In a second stage a selection has to be made of technology and practices to be demonstrated, while in a third stage the practical demonstration and training should be organized. The third stage can be linked to a practical training and demonstration centre for horticulture as discussed in the previous paragraph.

- *Healthy plant material*

The use of healthy plant material (seeds and seedlings) with have been produced under hygienic and controlled conditions are another crucial factor to boost the development of the horticultural sector. Currently a large share of growers relies still on self-propagated open pollinated seeds and grow their own seedlings under primitive and improvised conditions. In the more far future the shift to hybrid seeds will bring a major step in increasing crop yields.

Picture: Small nursery of vegetable grower, Tokar.

A huge step forward can be made if growers will be instructed on proper ways to propagate own seeds and raise seedlings. Even better is when they start buying seeds and seedlings from (more) professional operating nurseries. The introduction of quality standards and a control and certification system will be of major importance.

Dutch organizations like NakTuinbouw in close cooperation with seed companies could be involved in an intervention to improve the quality of locally propagated seeds and seedlings.

- *Compost*

In order to maintain soil fertility and improve soil structure and water retention capacity, it is important that farmers start to prepare and apply compost, made of local available vegetal residuals

and manure. The application of compost is especially recommended for land that is not flooded by rivers and is essential for organic farming. An experienced company like Soil & More International can cooperate with the introduction of good compost.

- *Agroforestry*

Combining the production of vegetable crops with growing of tree crops will be very important for the East Sudan region as part of an overall strategy to combat climate change and reversing the trend of deforestation from the last 5 decades in particular in Gedaref State.

A need for demonstration and training exists. An inventory of high potential tree crops has to be made. Such crops can include Arabic gum, tamarind, mango and citrus. The introduction of tree crops like cashew nut and almond should be investigated. Relevant questions to answer include:

- Are local climate conditions suitable enough for growing of these nut crops?
- Which varieties are suitable?
- How should a supply chain for growing of these nut crops look like?

6.2 Linking Dutch business to development potential

As has been indicated previously the involvement of Dutch companies in the development of the (East) Sudanese horticultural sector can be multiple. The opportunities can include:

- *Knowledge transfer and training*
  The involvement of Dutch companies can be linked to the establishment of a practical training and knowledge transfer centre for horticulture.

- *Supply of vegetables seeds*
  Vegetable seeds of Dutch origin have a good name in Sudan. With the growth of the population and interest of growers a market for open pollinated certified seeds of Dutch origin as well as hybrid seeds exists. The introduction of high productive, locally adapted varieties will be important to boost local production in the future and increase the efficiency and competitiveness (lower costs price). Currently Dutch-Dutch related companies as Pop Vriend, East West Seeds and Syngenta are already active on the market. Companies like Enza Zaden, Rijk Zwaan and Bejo Zaden will be interested. The involvement of a Dutch seed company can be linked to the development of a crop specific supply chain like for onion, carrot or galia melon.

- *Biological crop protection products*
  A company like Koppert Biological Systems is very active in Ethiopia and could be interested to introduce its biological control and plant enhancing products once government regulation will allow. Currently Koppert is exploring the Sudanese market.

- *Water storage and water saving solutions*
  Dutch horticultural companies are highly innovative and currently water saving and improvement of water efficiency are key topics. Innovative solutions combine water saving with renewable energy (solar). In this field high competition from Israeli as well as Saudi

companies can be foreseen.

- *Post-harvest handling*
  Dutch companies are leading in sorting and packaging solutions for horticultural crops. The expertise comprise sorting & packaging lines for fruits & vegetables (Greefa, Aweta, Perfect) lines for cutting, drying and freezing as well as storage of vegetables and fruits (Omnivent, Agrovent, Geerlofs, Celtic). In Kenya Omnivent and Hanze Staalbouw introduce basic and affordable storage technology for storage of table and seed potatoes.

- *Agro-logistics*
  The Netherlands is a world player in logistics with specific expertise in agro-logistics. The experience in organizing the production, post-harvest handling, distribution and sales/marketing of horticultural products in agro-logistic parks or so-called greenports can be very useful for Sudan where an organized structure for the storage, handling and distribution of fruits and vegetables is completely lacking. The wider Khartoum area would be a good location for the development of a pilot in this field. Another pilot could be set up nearby Port Sudan harbour (close to the harbour and international airport). Another potential location for an agro-logistic facility can be Aroma, centrally located between the Gash, New Halfa and future Atbara Seteit irrigation schemes on the main road to Port Sudan.

Annexes

Annex 1: Terms of Reference

Terms of Reference K2K16SD51 Horticulture Study East-Sudan	
Country	Sudan
Counterpart (s)	Sudanese Horticulture sector and relevant stakeholders
Beneficiary (ies)	- Netherlands Embassy in Khartoum - Sudanese Horticulture sector, especially the farmers involved in the 2g@there-OS project in Kassala - Members of the Netherlands Sudanese Agri Link (NSAL), involved in the 2g@there-OS project in Kassala - Dutch horticulture sector
Project information	
Project purpose	• Insight in possibilities to develop the horticulture sector in East Sudan in order to create sustainable employment for the Sudanese as well as the refugees in the region. • Insight in how the Dutch private sector can contribute to the development of the horticulture sector by exchange of knowledge, techniques and agro inputs.
Institutional setting	Stakeholders to be involved and/or interviewed (non-exclusive): - Dutch Embassy in Khartoum - Netherlands Sudanese Agri Link (NSAL) - Impact HUB in Khartoum (IHK) - Relevant farmers co-operations in Kassala and Red Sea State - Agricultural Research Centre in Kassala - Agricultural Universities in New Halfa and Kassala - Dutch horticulture and agro-food sector (Topsectors) (Contact details available at RVO and /or the Dutch Embassy.)
Problem analysis	East Sudan is a region that is particularly affected by migration influxes, especially out of Eritrea and Ethiopia. In 2015, the EU and five partner countries (Egypt, Eritrea, Ethiopia, South Sudan, Sudan) started the Khartoum Process, aimed at establishing a dialogue on migration and mobility. The Netherlands Embassy and Ministry of Foreign Affairs are involved in this dialogue while trying to promote the creation of employment and economic perspectives for migrants, sedentary migrants in refugee camps and young people, in the agricultural sector, by means of focused transfer of knowledge, expertise and technology, as well as the promotion of investment. There is a large interest in the knowledge, expertise and technology that Dutch businesses and knowledge institutions can transfer to achieve the goals of increased food production and employment. In various places, there is an existing infrastructure, such as irrigation schemes and warehouses, however not always utilised according to its capacity. Certainly, there is a large interest in the knowledge, expertise and technology that Dutch businesses and knowledge institutions can transfer to achieve the goals of increased food production, value addition, diversification, increased robustness and adaptation to climate change in combination with the creation of meaningful and valuable employment and economic perspectives. The Netherlands Embassy in Khartoum would like to have a study and road map to sketch an integrated approach that address these issues, with clear

	areas of intervention for the Dutch private sector. This study should focus on *concrete* business cases and opportunities for the Dutch private sector. The study should take place in the regions: Kassala (Girba/New Halfa scheme, Gash Delta), Red Sea Region (Tokar Delta) Special focus should be on Kassala where the potato production is introduced NSAL is involved in the 2g@there-OS project. The 2g@there-OS programme overall objectives are to contribute to the development of the local business climate and strengthen the local smallholder farms in Sudan and in Kassala in particular in the cultivation of potatoes. After a successful first growing season (November 2015 – March 2016), which has shown there is potential for potato production in Kassala, it would be interesting to see how the potato production would fit into the business model of the local farmers. For instance by rotating potatoes with other local crops like unions or tomatoes.
Results	A horticulture study containing a description of: 1- Agro-ecological Zones: This aspect can be shortly addressed since there are already several studies available on this topic (f.i. UNDP studies) 2- Cropping Systems: an overview of the crops that are already cultivated and opportunities for other crops, like potatoes. 3- Social Aspects: emphasis on horticulture (tuinbouw en fruitteelt). Pastoral aspects will be addressed in another dairy study that is currently being carried out by the Friesian). 4- Current agribusiness initiatives: with focus on horticulture (tuinbouw en fruitteelt). 5- Bottle necks in value chains: finance, transport & infrastructure, human resource. 6- Opportunities for scaling up, but with focus on access to markets as top priority. The production can be improved, but if no access to markets nothing will have been achieved. 7- Concrete business cases and opportunities for (Dutch) businesses.
Activities (non-exclusive)	- Desk studies - Interviewing - Field research - Reporting

Annex 2: Itinerary field trip

Date	Travel	Programme
THU 2 FEB	*Travel to Khartoum – arrival (+1) 02:10 am* **NB. Register passports!** Stay in Khartoum (Canon Hotel)	
FRI 3 FEB	Khartoum	10:30 Visits in Khartoum: Plants, West Omdurman, Bahri 16:00 Meeting with Impact Hub Khartoum
SAT 4 FEB	Port Sudan	??? DG Horticulture 11:00 Presentation by Dr ElKhidir on water in the East 15:00 Fly to Port Sudan (NOVA Airlines) – driver (Awad) and Osman will be there (Fri) Stay in Port Sudan (Palace Hotel)
SUN 5 FEB	Tokar	Travel to Tokar (2 hrs) Meetings/visits in Tokar (scheme managers, farmers/farms, EU-funded tomatoe factory) *Wrap-up meeting with stakeholders at end of the day* Stay in Tokar (home stay)
MON 6 FEB	Kassala	Travel to Kassala (5-6 hrs) Meetings/visits in Kassala town (East and West Gash) Stay in Kassala (Tulus Hotel or other)
TUE 7 FEB	Kassala	Morning: meetings/visits in Gash Delta and Aroma (Gash HQ) Afternoon: meetings with MinAgro, ARC, University of Kassala followed by further meetings/visits (incl. potatoe project) *Wrap-up meeting with stakeholders at end of the day* Stay in Kassala (Hotel Tulus or other)
WED 8 FEB	New Halfa	Travel to New Halfa (1 hr) Meetings/visits in New Halfa (scheme managers, farmers/farms) *Wrap-up meeting with stakeholders at end of the day* Stay in Girba (home stay)
THU 9 FEB	Girba + Shuwak	Morning: meetings/visits in Girba Afternoon: meetings/visits in Shuwak Stay in Gedaref (hotel)

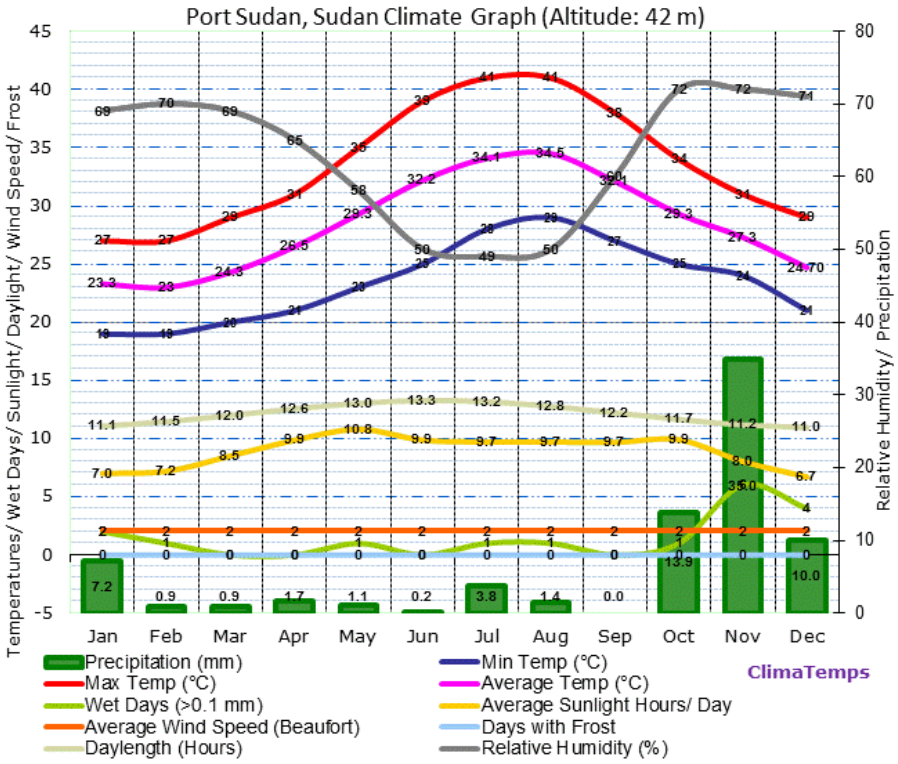
FRI 10 FEB	Faw + Rahad	Travel to Faw/Rahad Meetings/visits in Faw/Rahad Stay in Wad Medani (hotel)
SAT 11 FEB	Gezira *Return to Khartoum*	Meetings/visits in Gezira (informal): ARC, HRC, farmers/farms
SUN 12 FEB	Khartoum	Meeting/visits Khartoum: DAL Group, CTC nursery etc.
MON 13 FEB	Khartoum	??? Meeting KEY2MARKET ??? Meeting DG Horticulture 14:30 Debriefing for stakeholders 18:00 Farewell dinner
TUE 14 FEB	*Return to AMS – departure 03:05 am*	

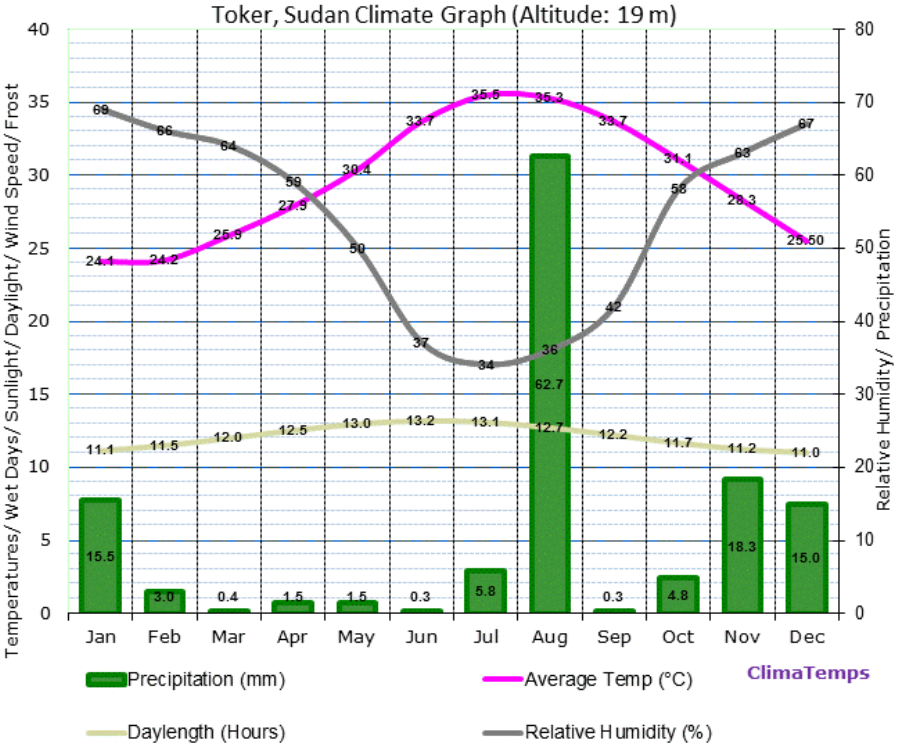
Annex 3: Climate in East Sudan

A summary is given of the annual climate indicators of various locations in East Sudan. The climate is indicated according the Köppen-Geiger classification and the biome according the bioclimatic classification of the Holdridge Life Zones System. *(Source: www.sudan.climatemps.com)*

Location	Latitude	Longitude	Altitude (m)	Climate (Köppen)	Biome (Holdridge)	Average Temperature (oC)	Total Precipitation (mm)
Port Sudan	19°35'N	37°13'E	42	BWh	Subtropical desert	28	76
Toker	18°26'N	37°44'E	19	BWh	Tropical desert	30	129
Aqiq	18°14'N	38°11'E	2	BWh	Tropical desert	30	125
Aroma	15°50'N	36°9'E	431	BWh	Tropical desert scrub	29	194
Kassala	15°28'N	36°24'E	500	BWh	Tropical thorn woodland	30	251
Halfa El Gedida	15°19'N	35°36'E	451	BWh	Tropical thorn woodland	29	238
El Showak	14°24'N	35°47'E	510	BSh	Tropical very dry forest	29	502
Gedaref/Azaza	14°2'N	35°24'E	599	BSh	Tropical very dry forest	29	604
Wad Medani	14°24'N	33°29'E	408	BWh	Tropical thorn woodland	29	306
Khartoum	15°36'N	32°33'E	380	BWh	Tropical desert scrub	30	162

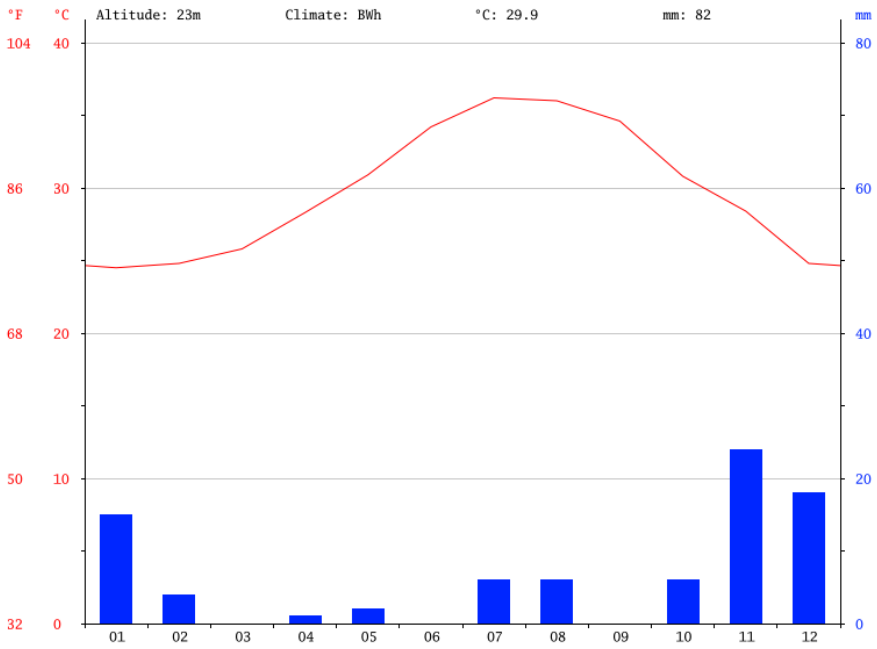
The seasonal variation of the major climate indicators of each location is shown in the graphs below:



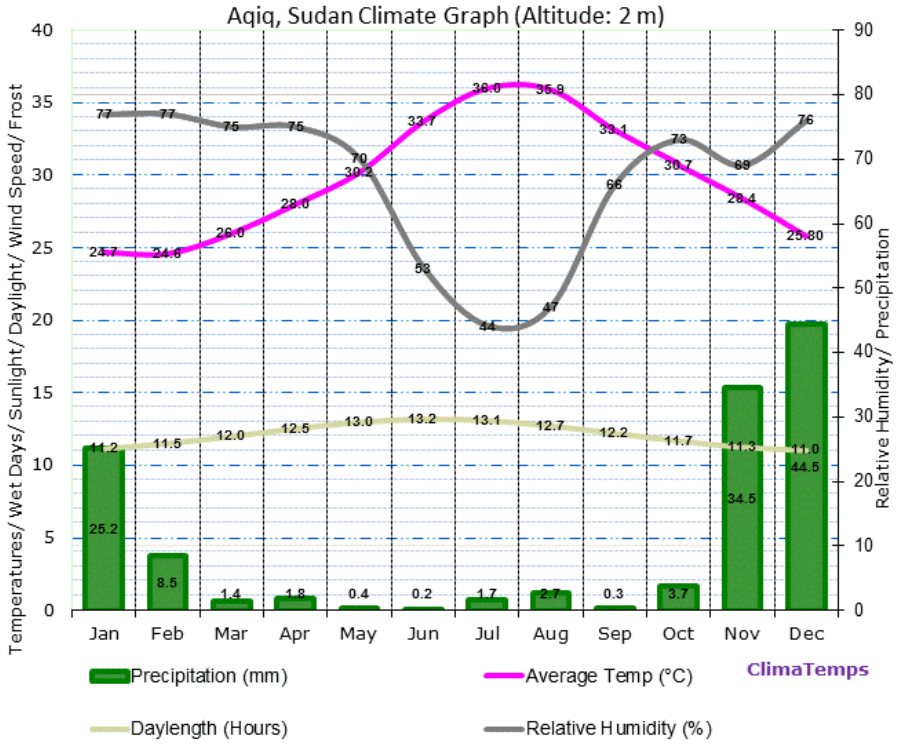


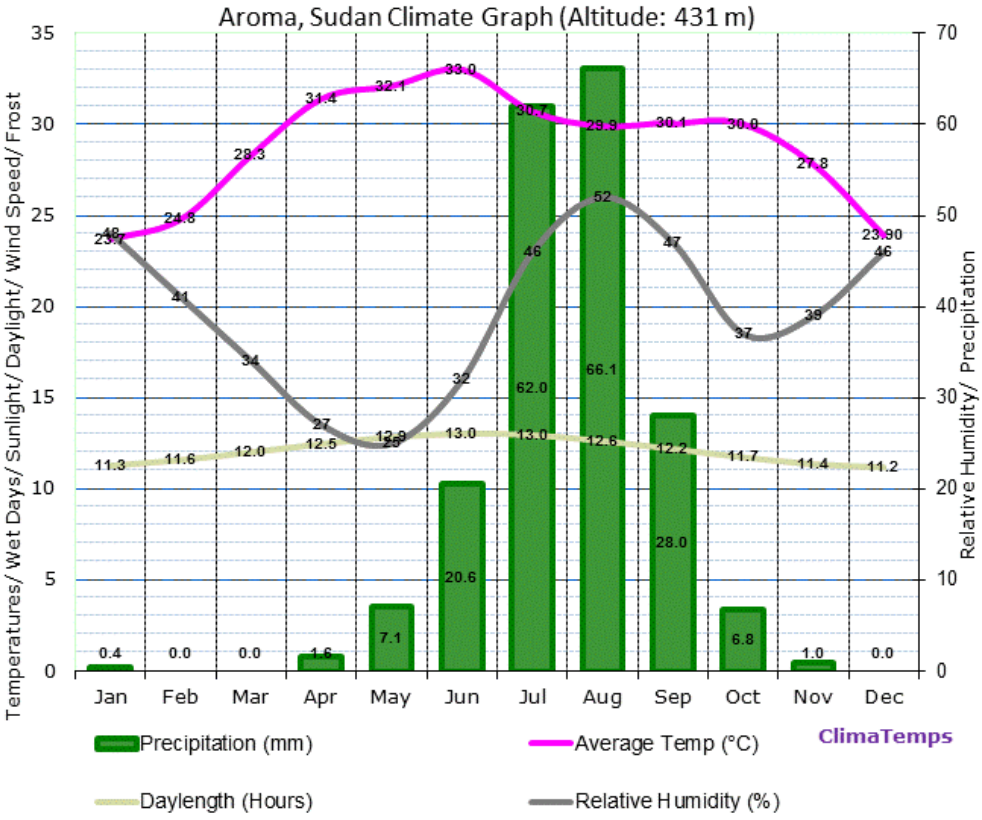
N.B. The impression exists that the precipitation bar of August is an error or a very incidental occurrence.
The rain pattern of Tokar is normally similar to that of Port Sudan and Aqiq (see below). Therefor we attach still a climate graph of another source: www.climate-data.org.

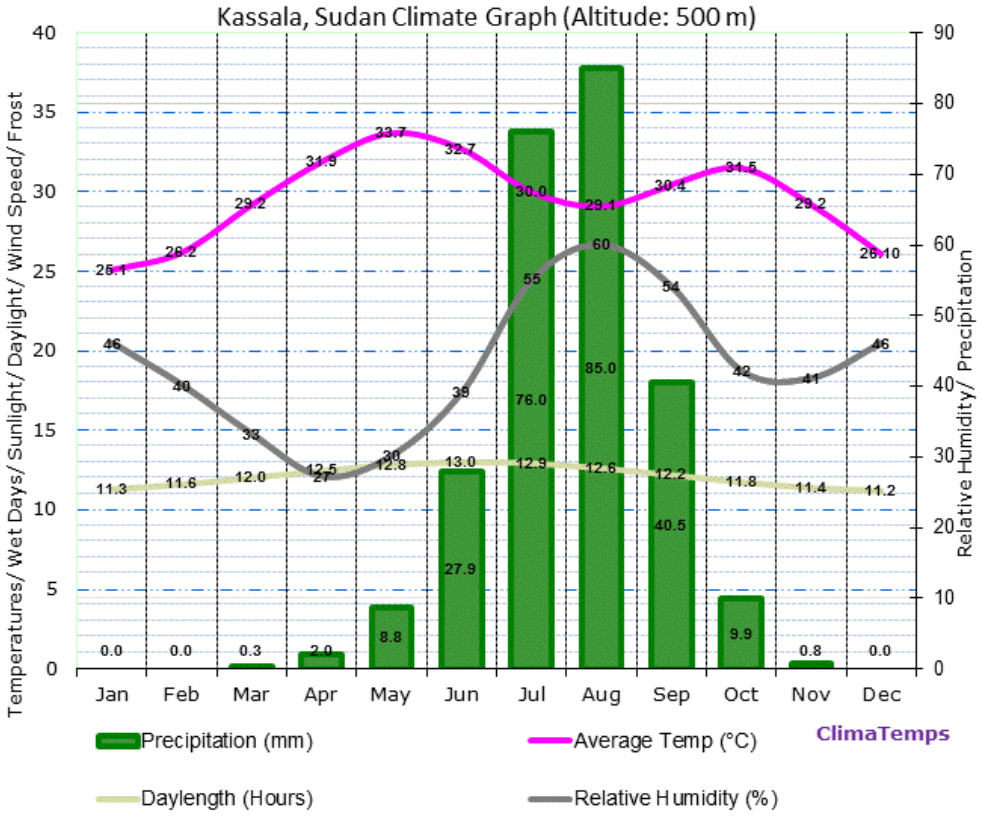
ALTERNATIVE CLIMATE GRAPH TOKAR (www.climate-data.org)

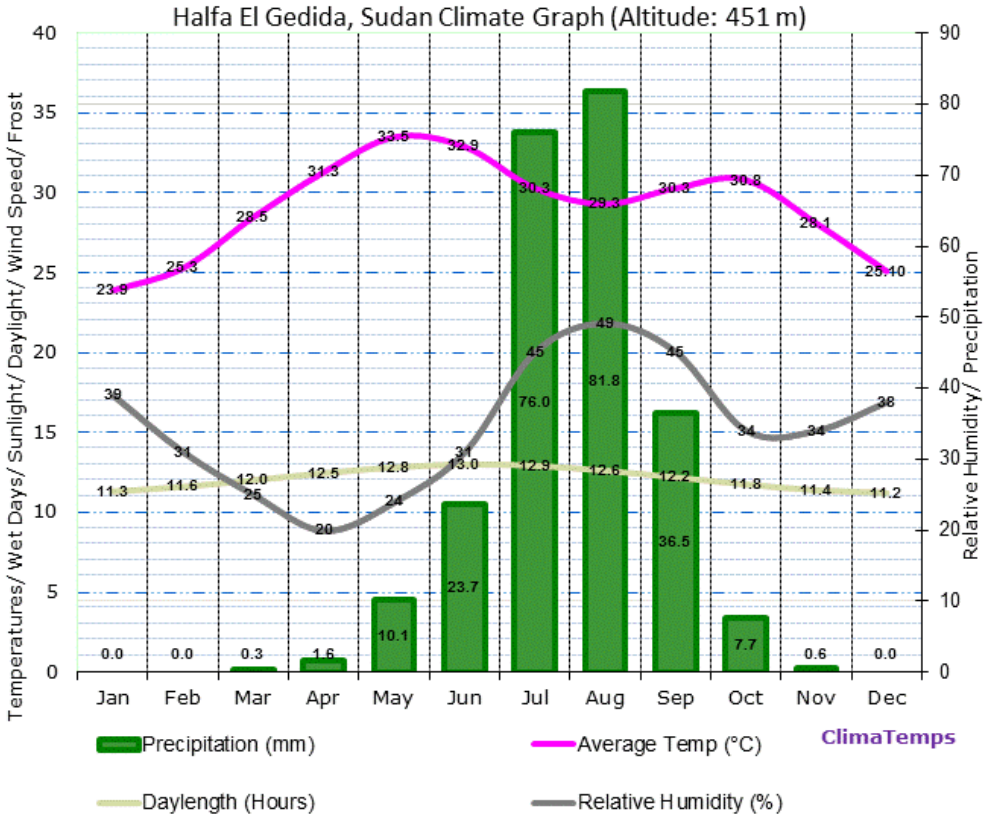


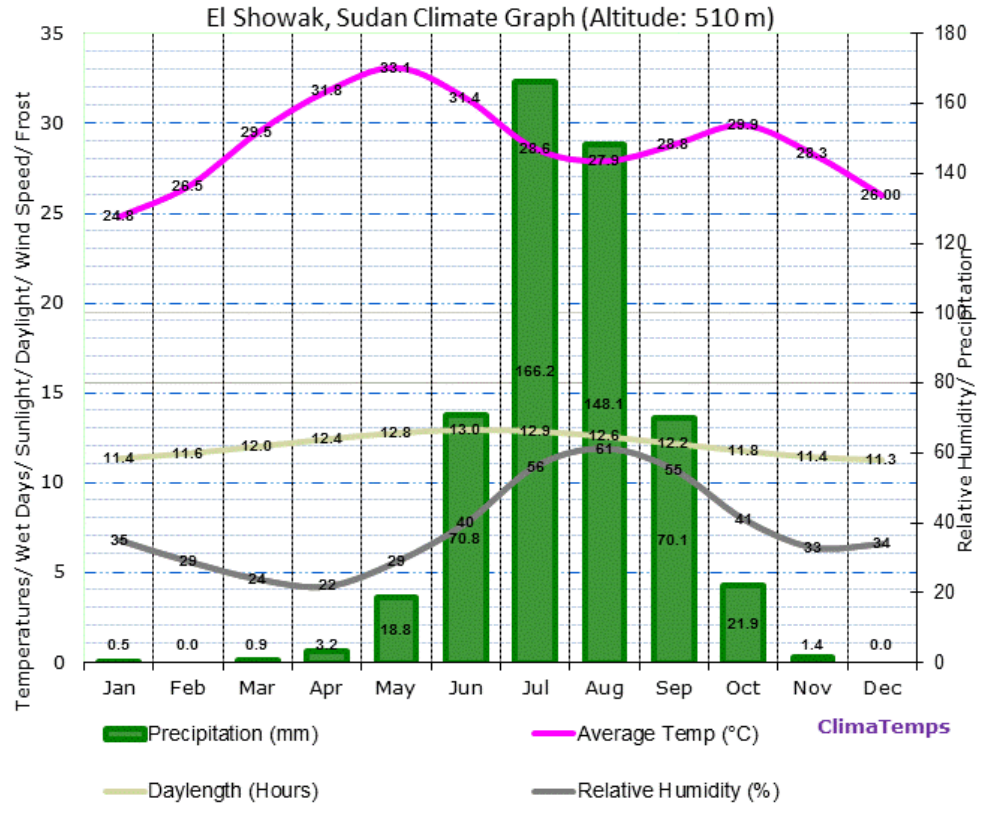
Blue: precipitation (mm) Red: average temperature (°C)

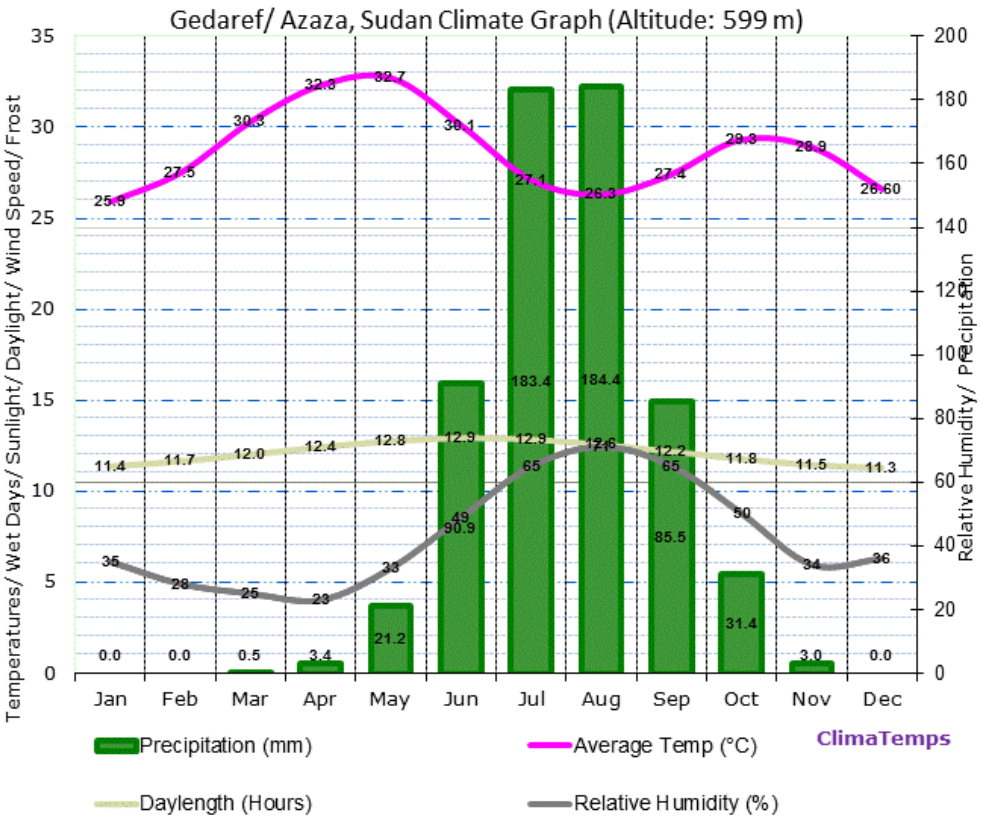


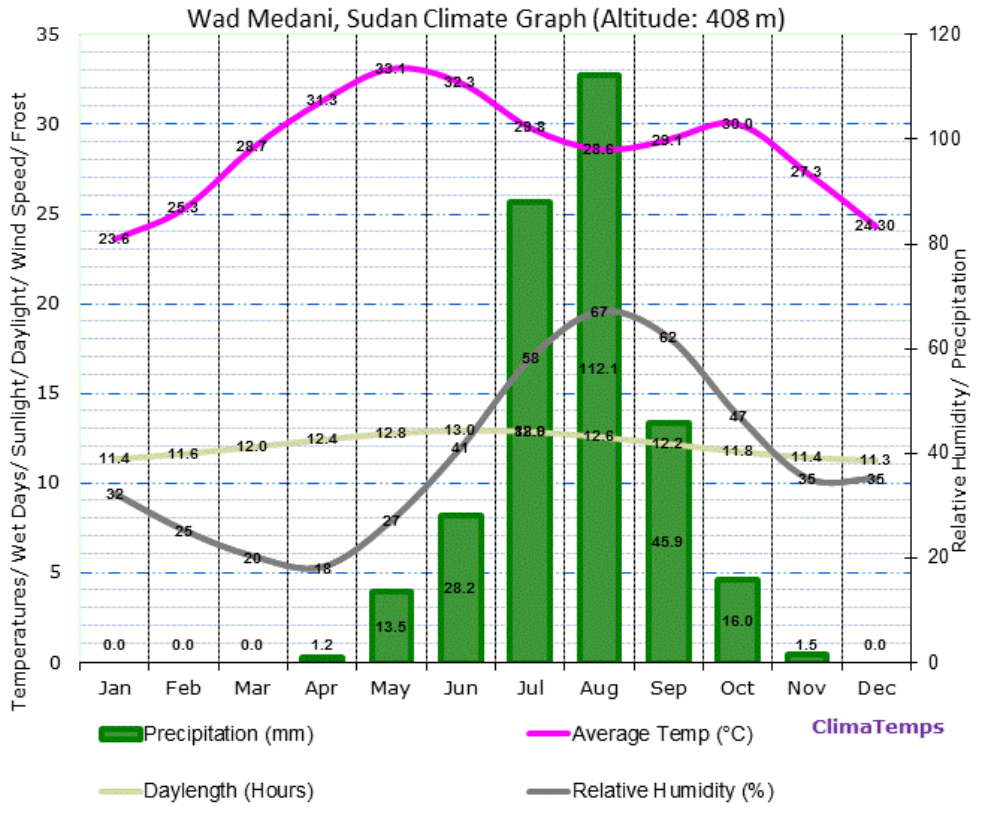

Aroma, Sudan Climate Graph (Altitude: 431 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
0.4 0.0 0.0 1.6 7.1 20.6 62.0 66.1 28.0 6.8 1.0 0.0
23.7 24.8 28.3 31.4 32.1 33.0 30.7 29.3 30.1 30.0 27.8 23.90
11.3 11.6 12.0 12.5 12.9 13.0 13.0 12.6 12.2 11.7 11.4 11.2
48 41 34 27 25 32 46 52 47 37 39 46
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps

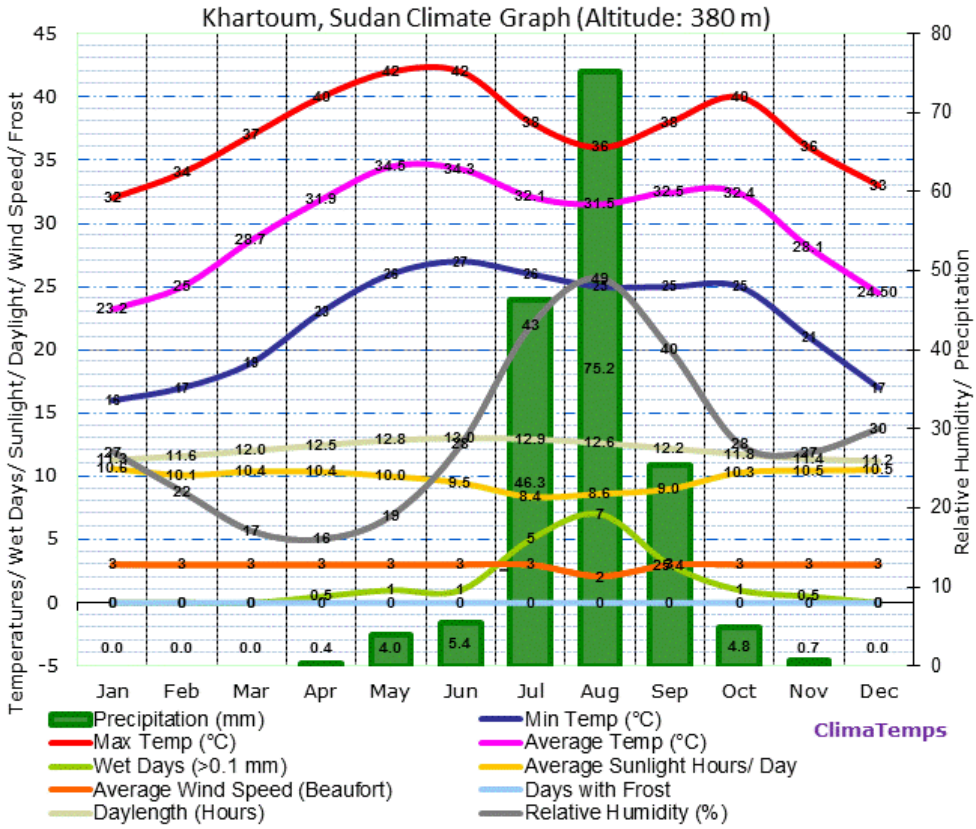

Kassala, Sudan Climate Graph (Altitude: 500 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
0.0 0.0 0.3 2.0 8.8 27.9 76.0 85.0 40.5 9.9 0.8 0.0
25.1 26.2 29.2 31.9 33.7 32.7 30.0 29.1 30.4 31.5 29.2 26.10
11.3 11.6 12.0 12.5 12.8 13.0 12.9 12.6 12.2 11.8 11.4 11.2
46 40 33 27 30 38 55 60 54 42 41 46
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps


Halfa El Gedida, Sudan Climate Graph (Altitude: 451 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
23.8 25.3 28.5 31.3 33.5 32.9 30.3 29.3 30.3 30.8 28.1 25.10
11.3 11.6 12.0 12.5 12.8 13.0 12.9 12.6 12.2 11.8 11.4 11.2
39 31 25 20 24 31 45 49 45 34 34 38
0.0 0.0 0.3 1.6 10.1 23.7 76.0 81.8 36.5 7.7 0.6 0.0
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps


El Showak, Sudan Climate Graph (Altitude: 510 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
24.8 26.5 29.5 31.8 33.1 31.4 28.6 27.9 28.8 29.9 28.3 26.00
11.4 11.6 12.0 12.4 12.8 13.0 12.9 12.6 12.2 11.8 11.4 11.3
35 29 24 22 29 40 56 61 55 41 33 34
0.5 0.0 0.9 3.2 18.8 70.8 166.2 148.1 70.1 21.9 1.4 0.0
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps

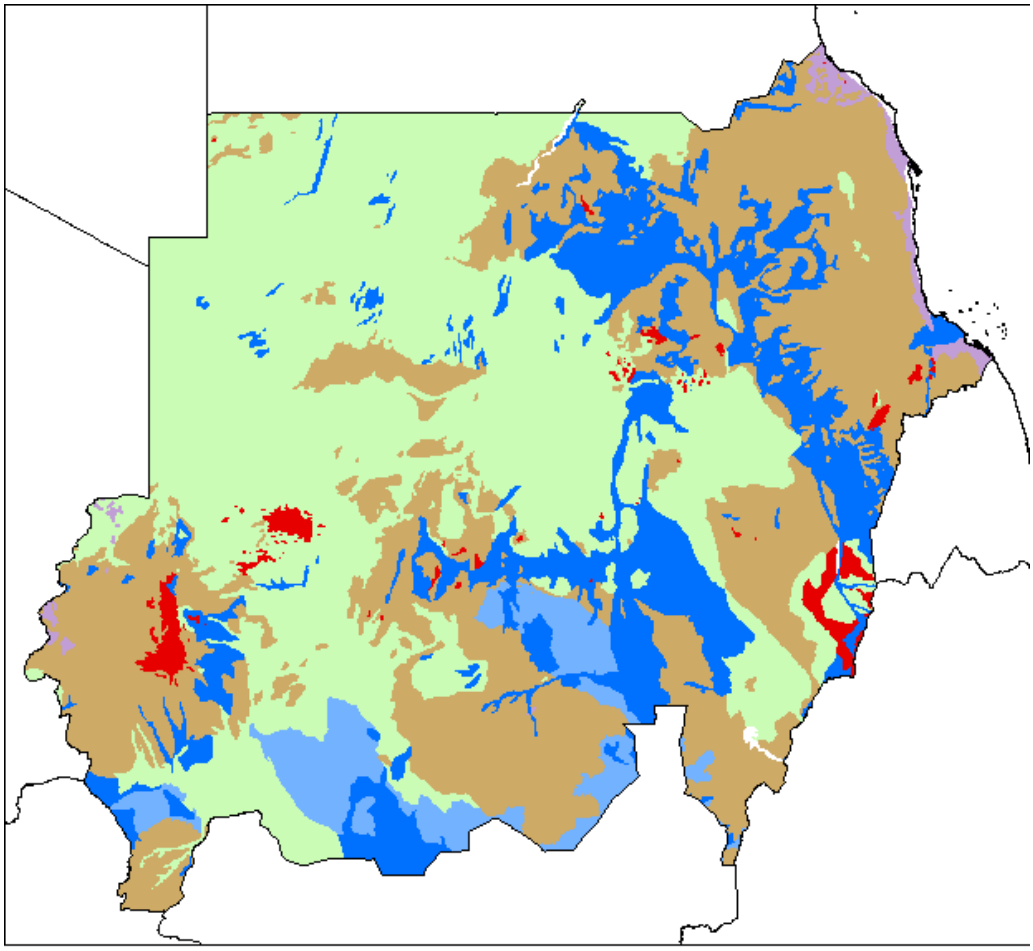

Gedaref/ Azaza, Sudan Climate Graph (Altitude: 599 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
25.9 27.5 30.3 32.3 32.7 30.1 27.1 26.3 27.4 29.3 28.9 26.60
11.4 11.7 12.0 12.4 12.8 12.9 12.9 12.6 12.2 11.8 11.5 11.3
35 28 25 23 33 49 65 72 65 50 34 36
0.0 0.0 0.5 3.4 21.2 90.9 183.4 184.4 85.5 31.4 3.0 0.0
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps


Wad Medani, Sudan Climate Graph (Altitude: 408 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
23.6 25.3 28.7 31.3 33.1 32.3 29.3 28.6 29.1 30.0 27.3 24.30
11.4 11.6 12.0 12.4 12.8 13.0 12.8 12.6 12.2 11.8 11.4 11.3
32 25 20 18 27 41 58 67 62 47 35 35
0.0 0.0 0.0 1.2 13.5 28.2 112.1 45.9 16.0 1.5 0.0
Precipitation (mm)
Average Temp (°C)
Daylength (Hours)
Relative Humidity (%)
ClimaTemps


Khartoum, Sudan Climate Graph (Altitude: 380 m)
Temperatures/ Wet Days/ Sunlight/ Daylight/ Wind Speed/ Frost
Relative Humidity/ Precipitation
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Precipitation (mm)
Max Temp (°C)
Wet Days (>0.1 mm)
Average Wind Speed (Beaufort)
Daylength (Hours)
Min Temp (°C)
Average Temp (°C)
Average Sunlight Hours/ Day
Days with Frost
Relative Humidity (%)
ClimaTemps

Annex 4: Hydrogeology of Sudan

The hydrogeology map of Sudan at 1:5 million scale shows a simplified overview of the type and productivity of the main aquifers at a national scale.



Unconsolidated

Aquifer Productivity	Named Aquifers and General Description	Water quantity issues	Water quality issues	Recharge
Low to High Productivity	These unconsolidated sedimentary deposits consist of unconsolidated alluvial sands, silts, gravels and clays of Quaternary to Late Tertiary age, including the Gezira, Atshan and **Gash formations**. Aquifer properties are variable, depending largely on lithology, but where the alluvium is dominated by coarser grained deposits, can be high. The aquifers are typically unconfined. Water table depth ranges from 15 m to 40 m. Boreholes range between 30 m and 150 m deep. The **Gash aquifer** is generally around 60 m thick. Transmissivity values of 1000 m²/day have been reported (UN 1988). The Gezira and Atshan aquifers are around 80 m thick. Transmissivity values of between 500 and 1500 m²/day have been given for alluvial aquifers in Darfur and the north of Sudan (UN 1988).		Water quality is usually good and fresh.	During high flow periods, significant recharge to the Gezira and Atshan aquifers occurs by leakage from Blue and White Nile rivers ; and **to the Gash aquifer from the Gash river.**
Low to Moderate Productivity	The Um Ruwaba Formation forms an unconsolidated aquifer that covers a large area, and is generally of low to moderate productivity. The properties of the aquifer vary depending largely on lithology. Yields are generally lower than from consolidated sedimentary aquifers in Sudan. The aquifer can be unconfined, or locally semi-confined where permeable layers occur below clay strata at depth (UN 1988). Water table depth ranges from 10 m to 150 m. The aquifer can be several hundreds of metres thick, but boreholes range between 30 m and 150 m deep. It has a maximum transmissivity of 200 m²/day, and median of 25 m²/day. The storage coefficient is typically 10^{-5} to 10^{-3}. The aquifer is often in hydraulic contact with underlying Nubian Sandstone and older aquifers (UN 1988).	The aquifer is used mostly for small domestic supplies and livestock watering (UN 1988).	Water quality is usually good and fresh.	Recharge is dominantly from rainfall infiltration, and is relatively small.

Consolidated Sedimentary - Intergranular Flow

Aquifer Productivity	Named Aquifers and General Description	Water quantity issues	Water quality issues	Recharge
Low to High Productivity	The Nubian Sandstone Formation is a major regional aquifer. The water-bearing sandstone strata have relatively high intergranular permeability and storage. Aquifer thickness ranges from 100 m to 2000 m. Transmissivity values generally range from 100 to 300 m²/day, although values of between 35 and 1500 m²/day have been recorded (UN 1988).	Groundwater storage in the Nubian Sandstone aquifer in the Baggara basin is estimated at	Groundwater quality is generally fresh, although salinity	Recharge occurs by direct rainfall infiltration and via wadi runoff, and occasionally via leakage from the Nile rivers. Annual recharge to the Baggara basin is estimated at 30

	Specific yield ranges from 0.01 to 0.2, and storage coefficient from 10^{-3} to 10^{-4}. The aquifer is semi confined to confined. In some cases, groundwater was traditionally discharged via springs. Piezometric (potentiometric) groundwater head varies from 6 m below ground surface at Wadi Howar to 100 m deep at Baggara Basin. Boreholes are generally between 40 m and 400 m deep. Recorded borehole yields are between a few m³/hour to 400 m³/hour. The **Gedaref Sandstone Formation** is not distinguished from the Nubian Sandstone Formation on the maps above, but also has relatively high intergranular permeability, and also forms a moderately to highly productive aquifer. Aquifer thickness ranges from 100 m to 2000 m. Transmissivity values range from 100 to 300 m²/day. Specific yield ranges from 0.01 to 0.2, and storage coefficient from 10^{-3} to 10^{-4}. The aquifer is semi confined to confined. Boreholes are generally between 40 m and 400 m deep.	1,300,000 million m³, and in the Bara basin estimated at 45,000 million m³.	increases down-gradient and there are local pockets of higher salinity.	million m³, and to the Bara basin estimated at 15 million m³.

Consolidated Sedimentary - Intergranular & Fracture Flow

Aquifer Productivity	Named Aquifers and General Description	Water quantity issues	Water quality issues	Recharge
Low to Moderate Productivity	**Red Sea littoral sediments** are relatively consolidated marine sediments, including coral limestones. Aquifer permeability and storage is low. The saturated thickness of the aquifers is typically 5 m to 20 m, although the total thickness of the geological unit can exceed 1000 m. The aquifer is unconfined and the water table typically between 10 m and 30 m below the ground surface. Boreholes are generally between 10 m and 50 m deep.		Water quality is generally brackish.	Recharge is low.
Low to Moderate Productivity	Palaeozic sedimentary rocks occur mostly in small outcrops in western Sudan. They do not form major aquifers in Sudan, and little is known about them. Aquifer productivity is likely to be low and groundwater flow and storage only through fractures.			

Igneous Volcanic - Fractured Aquifer

Aquifer Productivity	Named Aquifers and General Description	Water quantity issues	Water quality issues	Recharge
Very Low to High Productivity	These aquifers include the **Gedaref basalts** and Jebel Mara volcanics. Groundwater occurs in fractured and weathered zones. They form variably thick and variably productive aquifers depending on the degree of permeability developed by fracture		Groundwater quality is typically fresh in shallow zones	Recharge is variable dependin g on

	and weathering, from a few metres to several hundreds of metres thick, and from very low to high aquifer productivity. The aquifers are typically unconfined. Boreholes abstracting water from the aquifer range from 10 m to 300 m deep.		to brackish in deeper aquifer zones.	rainfall and surface runoff.

Basement

Aquifer Productivity	Named Aquifers and General Description	Water quantity issues	Water quality issues	Recharge
Low Productivity	Groundwater occurs in fractures and/or in shallow weathered zones in Precambrian bedrock, where permeability has been increased. These aquifer zones are typically between 5 m and 20 m thick, but can be thicker. Water table depths range from 4 m to 60 m depth, and groundwater is typically unconfined. Abstraction boreholes range from 10 m to 70 m, and borehole yields are generally low.	The fractured/weathered aquifers have low storage potential and do not contain large amounts of groundwater.	Groundwater quality ranges from fresh to brackish.	Recharge is variable depending on rainfall and surface runoff.

Annex 5: Sudanese Horticultural Crop Calendar

Serial No.	Crop	Import ban period	Import permit period
I.	***Fruits***		
1	Mango	All year	-
2	Lime	All year	-
3	Mandarin (tangerine)	Sept.~March	April~August
4	Orange	Sept.~March	April~August
5	Grapefruit	All year	-
6	Banana	All year	-
7	Guava	All year	-
8	Fresh dates	June~March	April~May
9	Dry dates	All year	-
II.	***Vegetables***		
01	Tomato	All year	-
02	Potato	All year	-
03	Onion	All year	-
04	Muskmelon	All year	-
05	Watermelon	All year	-
06	Green Beans	Dec.~March	April~Nov.
07	eggplant	All year	-
08	zucchini	All year	-
09	Pumpkin	All year	-
10	Green Peas	Dec.~March	April~Nov.
11	Bell pepper	-	All year
12	Okra	All year	-
13	carrots	Oct.~April	May~Sept.
14	beets	Oct.~April	May~Sept.
15	radish	All year	-
16	cabbage	-	All year
17	Broccoli	-	All year
18	Dill	All year	-
19	Cucumber	All year	-
20	Snake cucumber	All year	-
21	Jew's mallow	All year	-
22	Sweet potato	All year	-
23	Purslane	All year	-
24	Arugula	All year	-
25	Melon seeds	All year	-
26	Chili peppers	All year	-

Serial No.	Crop	Import ban period	Import permit period
III.	***Herbal & Aromatic Plants***		
01	Garlic	Apr.~Aug.	Sept.~March
02	fennel	All year	
03	Black cumin	-	All year
04	Hibiscus	All year	
05	Senna	All year	
06	Henna	All year	
07	Frankincense olibanum	-	All year
08	Coriander	All year	-
09	fenugreek	March~May	June~February
10	Solenostemma argel	All year	-
11	Citrullus colocynthis	All year	-
12	tamarinde	All year	-
13	Grewia tenax	All year	-
14	baobab	All year	-
15	Desert dates	All year	-
16	Acacia nilotica seed pods	All year	-
17	chamomile	-	All year
18	Mint	All year	-
19	Dried Okra	All year	-
20	Anise	-	All year
21	lemongrass	All year	-
IV.	***Legumes***		
1	Broad beans	March~June	July~Feb.
2	Cannellini beans	March~July	Aug. ~Feb.
3	lentil	-	All year
4	Chickpea	March~July	Aug. ~Feb.
5	Yellow split peas	-	All year

(Source: Ministry of Agriculture and Forestry, Horticultural Sector Directorate)

Annex 6: Horticulture production figures of Sudan

Total area (Ha), production (tons) and calculated average annual yield (tons/Ha) of vegetables & fruits in Sudan

Vegetable crop	2010			2011			2012			2013			2014			2015		
	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)
Onion	58,6	1.116,0	19,0	59,6	1.036,0	17,4	69,6	1.324,8	19,0	75,8	1.443,2	19,0	82,5	1.575,0	19,1	86,0	1.583,4	18,4
Tomato	35,3	504,0	14,3	37,0	529,2	14,3	38,9	555,6	14,3	40,8	583,2	14,3	42,8	612,0	14,3	44,8	616,7	13,8
Okra	21,5	265,0	12,3	22,1	263,0	11,9	22,7	270,0	11,9	23,3	277,0	11,9	23,9	284,0	11,9	24,9	286,5	11,5
Eggplant	4,0	76,8	19,0	4,1	78,4	19,0	4,2	80,0	19,0	4,3	81,6	19,0	4,4	83,2	19,0	5,2	85,1	16,5
Potato	18,9	315,0	16,7	20,2	336,0	16,7	21,5	358,4	16,7	22,9	382,3	16,7	24,4	407,6	16,7	27,0	413,8	15,3
Sweet Potato	10,5	225,0	21,4	-	-	-	12,2	204,0	16,7	13,0	217,0	16,7	13,9	231,0	16,7	16,4	237,0	14,5
Melon	12,8	304,0	23,8	13,0	310,0	23,8	33,6	159,8	4,8	34,4	164,0	4,8	35,4	168,3	4,8	36,5	171,0	4,7
Cantaloupe	3,9	27,6	7,1	4,0	24,0	6,0	13,6	324,0	23,8	14,5	345,0	23,8	15,4	366,0	23,7	17,9	387,0	21,6
Pumpkin	8,5	203,0	23,8	8,6	205,0	23,8	4,1	29,4	7,1	4,2	30,3	7,1	4,4	31,2	7,1	5,6	32,1	5,7
Snake cucumber	10,5	175,0	16,7	10,9	182,0	16,7	8,7	207,0	23,8	8,8	209,0	23,8	8,9	211,0	23,8	9,2	213,0	23,1
Zucchini	2,7	13,0	4,8	2,8	13,4	4,8	11,3	189,0	16,7	11,8	196,0	16,7	12,2	203,0	16,7	13,6	210,0	15,4
Arugula	2,5	24,0	9,5	2,7	26,0	9,5	2,9	13,8	4,8	3,1	14,6	4,8	3,2	15,4	4,8	5,4	16,2	3,0
Jew's mallow	3,2	30,0	9,5	3,4	32,0	9,5	2,9	28,0	9,5	3,2	30,0	9,5	3,4	32,0	9,5	6,0	34,0	5,7
Purslane	2,6	25,2	9,5	2,9	28,0	9,5	3,6	34,0	9,5	3,8	36,0	9,5	4,0	38,0	9,5	6,2	40,0	6,4
Carrot	2,4	34,8	14,3	2,5	36,0	14,3	3,3	31,2	9,5	3,6	34,4	9,5	3,9	37,6	9,5	7,6	40,3	5,3
Beet	1,7	20,0	11,9	1,8	21,5	11,9	2,6	37,2	14,3	2,7	38,4	14,3	2,8	39,6	14,3	4,0	40,8	10,1
Green bell pepper	3,4	24,0	7,1	3,6	25,5	7,1	1,9	23,0	11,9	2,1	24,5	11,9	2,2	26,0	11,9	4,6	28,5	6,2
Green beans	1,3	9,6	7,1	1,4	10,2	7,1	3,8	27,0	7,1	4,0	28,5	7,1	4,2	30,0	7,1	4,4	31,5	7,1
TOTAL	**204,3**	**3.392,0**		**200,8**	**3.156,2**		**261,3**	**3.896,2**		**276,2**	**4.135,0**		**291,8**	**4.390,9**		**325,3**	**4.466,9**	
annual growth	-	-		*-2%*	*-7%*		*23%*	*19%*		*5%*	*6%*		*5%*	*6%*		*10%*	*2%*	

Fruit crop	2010			2011			2012			2013			2014			2015		
	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)	Area (1000 hectare)	Production (1000 tons)	Yield (tons/hectare)
Mango	29,1	624,6	21,4	29,4	630,0	21,4	29,7	635,4	21,4	29,9	640,8	21,4	30,5	641,6	21,1	30,7	941,7	30,6
Banana	23,9	684,0	28,6	26,3	750,0	28,6	28,8	822,0	28,6	31,5	900,0	28,6	35,3	909,0	25,8	39,8	910,0	22,9
Lime	16,0	228,0	14,3	16,8	240,0	14,3	17,6	252,7	14,3	18,5	264,0	14,3	20,2	268,0	13,3	23,6	269,5	11,4
Grapefruit	12,8	183,0	14,3	13,4	196,0	14,6	14,1	201,6	14,3	14,8	211,8	14,3	16,6	216,8	13,1	21,0	219,1	10,4
Orange	11,2	133,5	11,9	11,6	138,0	11,9	12,0	142,5	11,9	12,3	147,0	11,9	13,8	150,0	10,9	18,3	152,0	8,3
Date	36,2	431,0	11,9	36,4	433,5	11,9	36,6	436,0	11,9	36,8	438,5	11,9	37,0	439,0	11,9	37,1	439,1	11,8
Guava	7,8	129,5	16,7	8,0	131,0	16,4	8,2	136,5	16,7	8,4	140,0	16,7	9,5	142,5	15,1	14,1	144,2	10,2
*Others**	1,6	11,1	7,1	1,6	11,4	7,1	1,6	11,7	7,1	1,7	12,0	7,1	2,7	14,5	5,3	18,9	31,7	1,7
TOTAL	**138,60**	**2.424,7**		**143,5**	**2.529,9**		**148,6**	**2.638,4**		**154,0**	**2.754,1**		**165,4**	**2.781,4**		**203,6**	**3.107,3**	
annual growth	-	-		*4%*	*4%*		*4%*	*4%*		*4%*	*4%*		*7%*	*1%*		*23%*	*12%*	

**others include: mandarin, grapes and papaya.*

(Source: Ministry of Agriculture & Irrigation, General Directorate of Horticultural Production, Statistics & Data Section)

Total area (feddan), production (tons) and calculated average annual yield (tons/feddan) of vegetables & fruits in Sudan

Vegetable crop	2010			2011			2012			2013			2014			2015		
	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)
Onion	139,5	1.116,0	8,0	142,0	1.036,0	7,3	165,6	1.324,8	8,0	180,4	1.443,2	8,0	196,5	1.575,0	8,0	204,7	1.583,4	7,7
Tomato	84,0	504,0	6,0	88,2	529,2	6,0	92,6	555,6	6,0	97,2	583,2	6,0	102,0	612,0	6,0	106,7	616,7	5,8
Okra	51,2	265,0	5,2	52,6	263,0	5,0	54,0	270,0	5,0	55,4	277,0	5,0	56,8	284,0	5,0	59,3	286,5	4,8
Eggplant	9,6	76,8	8,0	9,8	78,4	8,0	10,0	80,0	8,0	10,2	81,6	8,0	10,4	83,2	8,0	12,3	85,1	6,9
Potato	45,0	315,0	7,0	48,0	336,0	7,0	51,2	358,4	7,0	54,6	382,3	7,0	58,2	407,6	7,0	64,3	413,8	6,4
Sweet Potato	25,0	225,0	9,0	-	-	-	29,0	204,0	7,0	31,0	217,0	7,0	33,0	231,0	7,0	39,0	237,0	6,1
Melon	30,4	304,0	10,0	31,0	310,0	10,0	79,9	159,8	2,0	82,0	164,0	2,0	84,2	168,3	2,0	86,8	171,0	2,0
Cantaloupe	9,2	27,6	3,0	9,5	24,0	2,5	32,4	324,0	10,0	34,5	345,0	10,0	36,7	366,0	10,0	42,7	387,0	9,1
Pumpkin	20,3	203,0	10,0	20,5	205,0	10,0	9,8	29,4	3,0	10,1	30,3	3,0	10,4	31,2	3,0	13,3	32,1	2,4
Snake cucumber	25,0	175,0	7,0	26,0	182,0	7,0	20,7	207,0	10,0	20,9	209,0	10,0	21,1	211,0	10,0	22,0	213,0	9,7
Zucchini	6,5	13,0	2,0	6,7	13,4	2,0	27,0	189,0	7,0	28,0	196,0	7,0	29,0	203,0	7,0	32,4	210,0	6,5
Arugula	6,0	24,0	4,0	6,5	26,0	4,0	6,9	13,8	2,0	7,3	14,6	2,0	7,7	15,4	2,0	12,9	16,2	1,3
Jew's mallow	7,5	30,0	4,0	8,0	32,0	4,0	7,0	28,0	4,0	7,5	30,0	4,0	8,0	32,0	4,0	14,3	34,0	2,4
Purslane	6,3	25,2	4,0	7,0	28,0	4,0	8,5	34,0	4,0	9,0	36,0	4,0	9,5	38,0	4,0	14,8	40,0	2,7
Carrot	5,8	34,8	6,0	6,0	36,0	6,0	7,8	31,2	4,0	8,6	34,4	4,0	9,4	37,6	4,0	18,0	40,3	2,2
Beet	4,0	20,0	5,0	4,3	21,5	5,0	6,2	37,2	6,0	6,4	38,4	6,0	6,6	39,6	6,0	9,6	40,8	4,3
Green bell pepper	8,0	24,0	3,0	8,5	25,5	3,0	4,6	23,0	5,0	4,9	24,5	5,0	5,2	26,0	5,0	11,0	28,5	2,6
Green beans	3,2	9,6	3,0	3,4	10,2	3,0	9,0	27,0	3,0	9,5	28,5	3,0	10,0	30,0	3,0	10,5	31,5	3,0
TOTAL	**486,5**	**3.392,0**		**478,0**	**3.156,2**		**622,2**	**3.896,2**		**657,5**	**4.135,0**		**694,7**	**4.390,9**		**774,6**	**4.466,9**	
annual growth	-	-		*-2%*	*-7%*		*23%*	*19%*		*5%*	*6%*		*5%*	*6%*		*10%*	*2%*	

Fruit crop	2010			2011			2012			2013			2014			2015		
	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)	Area (1000 feddan)	Production (1000 tons)	Yield (tons/feddan)
Mango	69,4	624,6	9,0	70,0	630,0	9,0	70,6	635,4	9,0	71,2	640,8	9,0	72,5	641,6	8,8	73,2	941,7	12,9
Banana	57,0	684,0	12,0	62,5	750,0	12,0	68,5	822,0	12,0	75,0	900,0	12,0	84,0	909,0	10,8	94,7	910,0	9,6
Lime	38,0	228,0	6,0	40,0	240,0	6,0	42,0	252,7	6,0	44,0	264,0	6,0	48,0	268,0	5,6	56,3	269,5	4,8
Grapefruit	30,5	183,0	6,0	32,0	196,0	6,1	33,6	201,6	6,0	35,3	211,8	6,0	39,5	216,8	5,5	50,1	219,1	4,4
Orange	26,7	133,5	5,0	27,6	138,0	5,0	28,5	142,5	5,0	29,4	147,0	5,0	32,9	150,0	4,6	43,5	152,0	3,5
Date	86,2	431,0	5,0	86,7	433,5	5,0	87,2	436,0	5,0	87,7	438,5	5,0	88,0	439,0	5,0	88,3	439,1	5,0
Guava	18,5	129,5	7,0	19,0	131,0	6,9	19,5	136,5	7,0	20,0	140,0	7,0	22,5	142,5	6,3	33,6	144,2	4,3
*Others**	3,7	11,1	3,0	3,8	11,4	3,0	3,9	11,7	3,0	4,0	12,0	3,0	6,5	14,5	2,2	45,0	31,7	0,7
TOTAL	**330,00**	**2.424,7**		**341,6**	**2.529,9**		**353,8**	**2.638,4**		**366,6**	**2.754,1**		**393,9**	**2.781,4**		**484,7**	**3.107,3**	
annual growth	-	-		*4%*	*4%*		*4%*	*4%*		*4%*	*4%*		*7%*	*1%*		*23%*	*12%*	

**others include: mandarin, gropes and papaya.*

(Source: Ministry of Agriculture & Irrigation, General Directorate of Horticultural Production, Statistics & Data Section)

Annex 7: List of sources

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Annex 8: List of contact details of persons interviewed

List of contact details of persons interviewed:

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Annex 9: Mission Report

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