Observatoire du Sahara et du Sahel
Sahara and Sahel Observatory

WATER
IN OUR REGIONS

September 2020

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Water in our regions \ Sahara and Sahel Observatory. _ Tunis: OSS, 2020. _ 120p.

ISBN: 978-9938-933-29-1

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4th cover photo: Mangrove, Diawling National Park, Mauritania

PREFACE

The Sahara and Sahel Observatory is an intergovernmental Organization with an international scope and an African vocation. Its main missions relate to natural resources (water and soil) and more recently, climate change.

Our 25 African member countries, which extend over a territory of North Africa from Senegal to Somalia are all, without exception, facing different kinds of water challenges ranging from structural unavailability of resources for some countries, to inadequate mobilization for other countries, not to forget all the intermediate and related difficulties.

The Observatory role that we play led us to release in 1995 and then in 2001, monographs on water resources. It is time, after almost twenty years, and especially on the occasion of the 20th anniversary of our presence in Tunis, to release another monograph.

Hoping to produce, at the present time, a perfectly accurate overview of the water resources situation and their uses in our area of intervention, would be totally unrealistic. We all know that our region greatly and chronically lacks reliable, up-to-date and above all available data.

We therefore made the deliberate choice to collect every bit of information we could find, from different recognized national or international sources, and to make sure it was processed. The innovation will lie in sharing this document on a collaborative Wikipedia-type platform that we have developed, in order to open it up to amendments or improvements. If the approach is properly adopted, we plan on extending it to several documents, in particular those produced by our Observatory Function.

The synthesis that we present is the result of several months of research, cross-analysis and discussions between the OSS teams. To my opinion, the document made it through bringing together, in a few pages, information and data that will give an overview on the water challenge in the region, and I hope that it can be useful to different reader categories.

Thank you for being indulgent for the weaknesses that you could possibly (surely....) find.

Thank you also and in advance, to all those who will choose to be part of this collaborative adventure, and who will send us their comments or their proposals.

I would also like to thank of course all those who, within the OSS, have contributed to the creation and editing of this book, in its traditional design, but also in its open computer format.

Enjoy reading!

Khatim KHERRAZ

Executive Secretary

The Sahara and Sahel Observatory (OSS)

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The Sahara and Sahel Observatory

Dune fixation, Rosso, Mauritania

THE SAHARA AND SAHEL OBSERVATORY

The Sahara and Sahel Observatory (OSS) is an international, intergovernmental organization with an African vocation, created in 1992, and established in Tunis (Tunisia) since 2000.

In 2020, the OSS includes 32 member States and 13 member organizations (international, sub-regional and non-governmental) **(Figure 1)** :

- 25 African countries: Algeria, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Côte d'Ivoire, Djibouti, Egypt, Eritrea, Ethiopia, Gambia, Guinea-Bissau, Kenya, Libya, Mali, Morocco, Mauritania, Niger, Nigeria , Uganda, Senegal, Somalia, Sudan and Tunisia.

- 7 non-African countries: Germany, Belgium, Canada, France, Italy, Luxembourg and Switzerland.

- 13 organizations:
  - Pan-African Agency of the Great Green Wall (PAAGGW)
  - International Action and Achievement Centre (CARI)
  - Regional Centre for Remote Sensing of North African States (CRTEAN)
  - Permanent Inter-State Committee for Drought Control in the Sahel (CILSS)
  - Lake Chad Basin Commission (LCBC)
  - Community of Sahel-Saharan States (CENSAD)
  - United Nations Convention to Combat Desertification (UNCCD)
  - Environment development action in the third world (ENDA)
  - Food and Agriculture Organization of the United Nations (FAO)
  - Intergovernmental Authority on Development (IGAD)
  - United Nations Educational, Scientific and Cultural Organization (UNESCO)
  - Sahel Desertification Network (ReSaD)
  - Arab Maghreb Union (AMU)

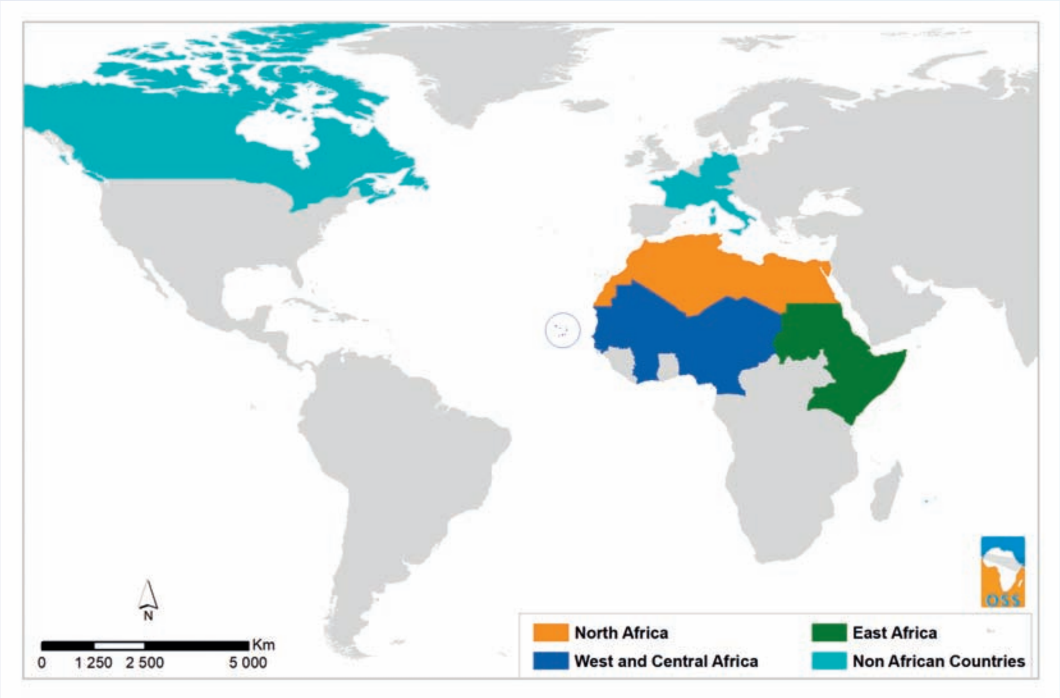

Figure 1. ***OSS member countries***

The OSS's current area of action[1] covers an approximately 17,52 million km^2 area, i.e. 57% of the African continent area[2]. The countries of West and Central Africa (Cameroon and Chad) account for 41% of the total area, those of North Africa 33%, and those of East Africa 26%. The area has a 22, 200 km long coastline *(OSS, 2020).*

Irrigated crops on a family farm, El Oued, Algeria.

[1] Under the OSS area of action, all African member countries.

[2] Between 30,330,000 km^2 and 30,415,873 km^2 including the islands, according to the authors. (http://www.atlas-monde.net/afrique/), https://www.francetvinfo.fr/monde/afrique/politique-africaine/la-carte-de-l-afrique-comme-vous-ne-l-avez-jamais-vue_3059425.html

One of the OSS missions is to support its African member countries in the integrated and consolidated management of their natural resources in a particularly disadvantageous climate change context.

This mission necessarily relies on knowledge transfer, capacity building and stakeholders' awareness-raising.

As part of its ten-year strategies, and more specifically its 2030 strategy, the OSS has committed to:

- Improve/strengthen knowledge of groundwater and surface water resources in the region, and their interactions, particularly with regard to shared water;
- Contribute to the establishment of planning tools to meet the water needs of the populations in the short, medium and long terms;
- Encourage and support integrated and sustainable water resources management policies;
- Contribute to improving and sustaining the governance of shared water resources;
- Contribute to place water on top of political agendas.

These commitments are consistent with the Sustainable Development Goals (SDGs) and the African Union's Agenda 2063.

1. GENERAL INTRODUCTION

Niger River tributary, Karey Gorou, Niger

1. GENERAL INTRODUCTION

1.1 Geographic area of the monograph

The OSS action covers the Sahara and Sahel area of Africa **(Figure 2)**. This area, where bioclimate varies from hyper-arid to humid **(Figure 3)**, extends in whole or in part over four sub-regions namely:

- North Africa[1] located at the crossroads of three continents; it includes the largest desert in the world (the Sahara with nearly 9 million km²). Its bioclimate varies from sub-humid to hyper-arid; it is influenced by the Mediterranean to the north, the Atlantic Ocean to the west, the Sahara to the south-central and to a lesser extent by the Sahel in southernmost portion of the area. Annual rainfall varies from 0.5 mm *(Luxor in Egypt)* to 1,600 mm *(Tangier in Morocco)*. Extreme temperatures were recorded in *Ain Salah in Algeria* (66˚C) and *Ifran in Morocco* (-23˚C). It is the driest region and the poorest in renewable water resources in the world and this increasingly affects its socio-economic development. Available freshwater resources represent approximately 0.7% of the world's total resources.

- West Africa[2] extends over a Sahel-Sahara area with savannahs, steppes and desert regions. The following main climate areas can be found (from north to south): *hyper-arid, arid, semi-arid, sub-humid and humid*. In the *hyper-arid (Sahara) area*, bordering the Sahara desert in its southern part, the cumulative annual rainfall does not reach 200 mm and the rainfall lasts only two months (mid-July to mid-September). The *arid climate* makes itself felt in the Sahel areas, where the annual rainfall levels do not exceed 600 mm with long-lasting dry seasons (up to 10 months). The *semi-arid climate* governs the Sahel-Sudan areas with average annual rainfall varying between 750 mm and 1,250 mm. The *humid climate* characterizes most of the coastal countries of the Gulf of Guinea and to a lesser extent, the southern areas of a number of Sahel countries with annual rainfall varying between 1,000 mm and 3,000 mm. Temperatures are generally high throughout the year, with a 25˚C average but can exceed 50˚C in the Sahel with a high daily amplitude.

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[1] **North Africa:** Algeria, Egypt, Libya, Morocco, Tunisia

[2] **West Africa:** Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal

Given the physical, climate and socio-demographic similarities, the two countries of Central Africa (Cameroon and Chad) will be associated with those of West Africa, in the rest of the analyses.

- Central Africa[3]: Cameroon has three types of climate (equatorial, Sudanese and Sudan-Sahel) with equatorial and Sudanese climate predominance. The annual rainfall varies from 500 mm (in the north) to 2,000 mm (in the south) and temperatures range between 20°C and 25°C. Chad is significantly drier than Cameroon, with a Sahara-Sahel climate predominance in the north and centre and the Sudanese climate in the southern part of the country. The annual rainfall varies following a north-south gradient from 100 mm to 1,200 mm and temperatures range between 20°C and 50°C.

- East Africa[4]: is known for its volcano-tormented landscape. It contains both the highest and the lowest points of the African continent (-153 m at the level of Lake Assal in Djibouti and +5,895 m at the level of the summit of Mount Kilimanjaro in Tanzania). It is home to many bodies of water, which is why it is called the “region of the great lakes”. The region climate varies between the *cool and humid conditions of the western highlands and the hot, arid and semi-arid conditions in the Horn of Africa parts* under the influence of the warm waters of the Indian Ocean. The upland areas receive the most abundant rainfall (1,500 mm/year to 2,000 mm/year) while in the Horn of Africa areas, they are significantly lower (less than 700 mm/year). In most regions, temperatures remain high throughout the year (28°C in average) with the exception of the mountainous areas in Ethiopia and Kenya with cooler temperatures (15°C in average).

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[3] **Central Africa:** Cameroon and Chad

[4] **East Africa:** Djibouti, Ethiopia, Eritrea, Kenya, Uganda, Somalia, Sudan

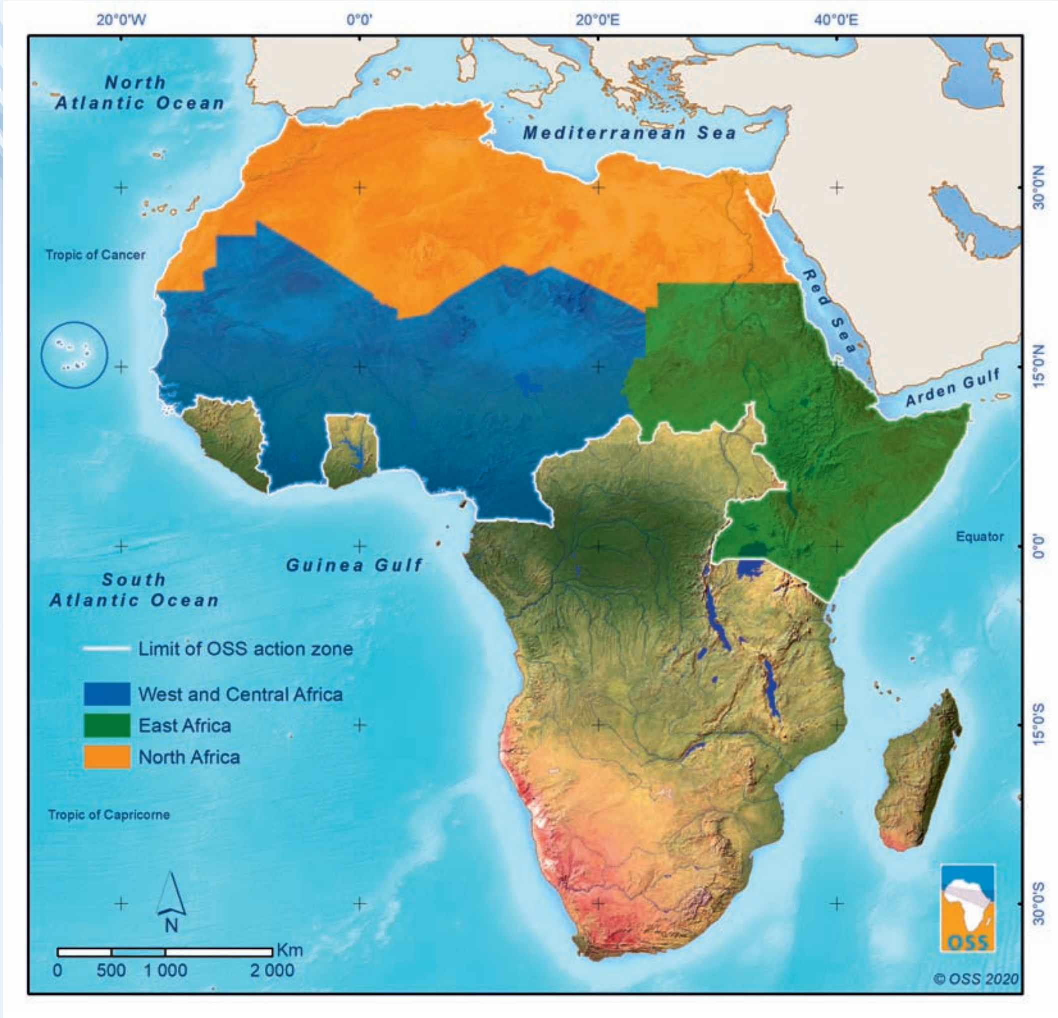

Figure 2. *OSS area of action*

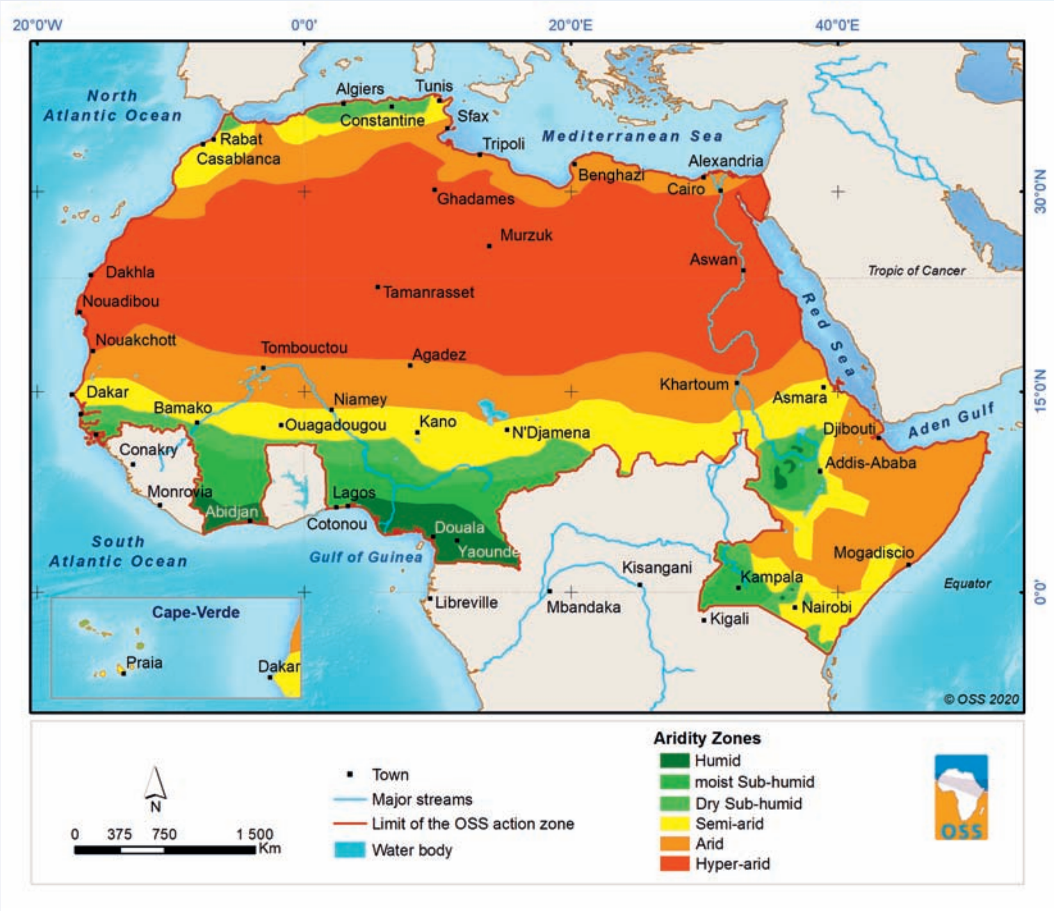

Figure 3. Aridity index map - *Data source: UNEP, 2009*

1.2 Socio-demographic characteristics of the area

The total population of the OSS area of action increased from 146 million inhabitants in 1950 to approximately 800 million inhabitants in 2019 (i.e. 61% of the total African population[5]) with an annual average growth rate of 2.5%. Urban population[6] is estimated at 40% of the total population of the OSS area of action, i.e. 320 million inhabitants and the rural population at 60%, i.e. 480 million inhabitants (WB, 2019; Knoema, 2019).

[5] In 2019, the total African population is estimated at 1.3 billion (https://www.worldometers.info/world-population/africa-population/, viewed on 06/07/2020)

[6] Urban population means all persons living in towns and villages of at least 1,000 inhabitants, whether or not these towns and villages are incorporated as municipalities (FAO, 2005, Mapping global urban and rural population distributions)

This population is unevenly distributed with a density ranging from 0 to more than 1,000 inhabitants per km^2 (Figure 4).

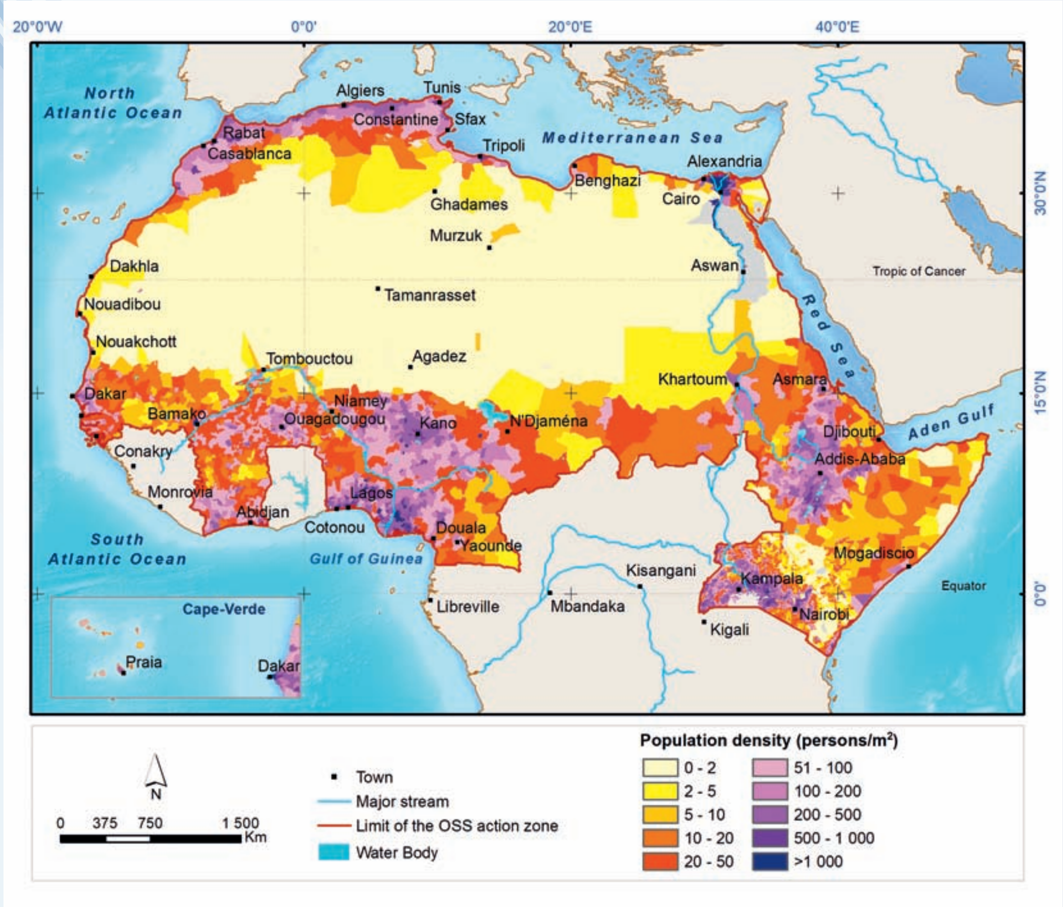

Figure 4. Map of average population density - *Data source: FAO & CIESEIN, 2009*

According to the United Nations prospects, the population of the OSS area of action will be approximately 1 billion inhabitants in 2030 and will approach 1.5 billion inhabitants in 2050, with an annual average growth rate of 2% (Figure 5).

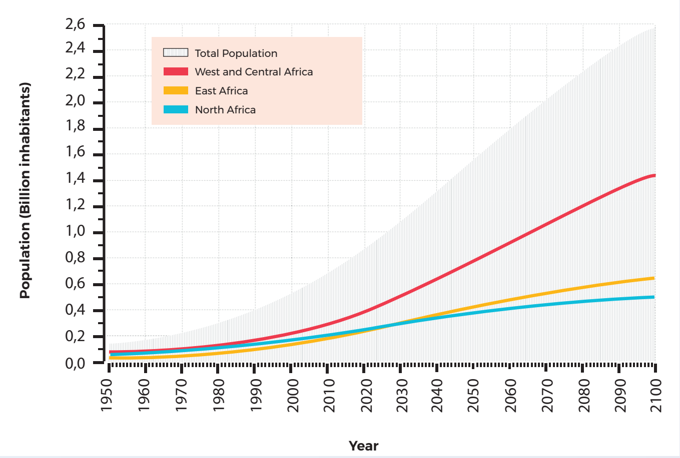

Figure 5. Population prospects - *Data source: UN, World Population Prospects, 2019*

In 2018, the economic and social development indicators in the OSS area of action are presented as follows **(UNDP, 2018)**:

- Life expectancy at birth increased from 41 years in 1960[7] to 66 in 2020[8], i.e. an average increase of more than 50%.
- The average infant mortality rate is 72‰ in 2020[9].
- Average gross domestic product per inhabitant (GDP[10]/inhabitant) was US$ 1,842, with a US$ 7,241 maximum and a US$ 314 minimum.
- Average human development index (HDI)[11] is 0.533 and varies between 0.37 and 0.76.
- As regards poverty, about 28% of the population in the area of action live below the US$ 1.25/day threshold (based on 2011 conversion rates in purchasing power parity - PPP).
- The malnutrition prevalence[12] ranges from 3.9% to 37.5%.
- In terms of education[13], the countries of the OSS area of action have an average school enrolment rate of 77.9%. Women represent 49.76% of the total number of students.

1.3 Main land use units in the area

According to recent OSS mapping works (2017), the main land use units in the area of action are shown in **Figure 6** and are distributed as follows:

- Desert areas with large expanses of dunes and rocky outcrops: 9,176,000 km^2, i.e. 51.88%;
- Natural vegetation (forest, savannah, scrubland, steppe, etc.): 6, 127,000 km^2, i.e. 34.64%;
- Agricultural area: 2, 056,000 km^2, i.e. 11.62%;
- Floodplain: 159,000 km^2, i.e. 0.90%;
- Body of water: 116,000 km^2, i.e. 0.66%;
- Housing: 53,200 km^2, i.e. 0.30%.

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7 http://perspective.usherbrooke.ca/bilan/servlet/BilanEssai?codetheme=3&codeStat=SP.DYN.LE00.IN&anneeStat1=1960&optionGraphique1=sans&logsUni=sansLogUni&codetheme2=2&codeStat2=x&couleurGraphique=Vert&taillePolices=11px&langue=fr&noStat=4

8 https://www.cia.gov/library/publications/resources/the-world-factbook/fields/355.html

9 https://www.cia.gov/library/publications/resources/the-world-factbook/fields/346.html#XX

10 https://donnees.banquemondiale.org/indicateur/NY.GDP.PCAP.CD?view=chart

11 https://www.populationdata.net/palmares/idh/afrique/

12 https://knoema.fr/WBWDI2019Jan/indicateurs-de-d%C3%A9veloppement-dans-le-monde

13 https://knoema.fr/atlas/topics/%c3%89ducation

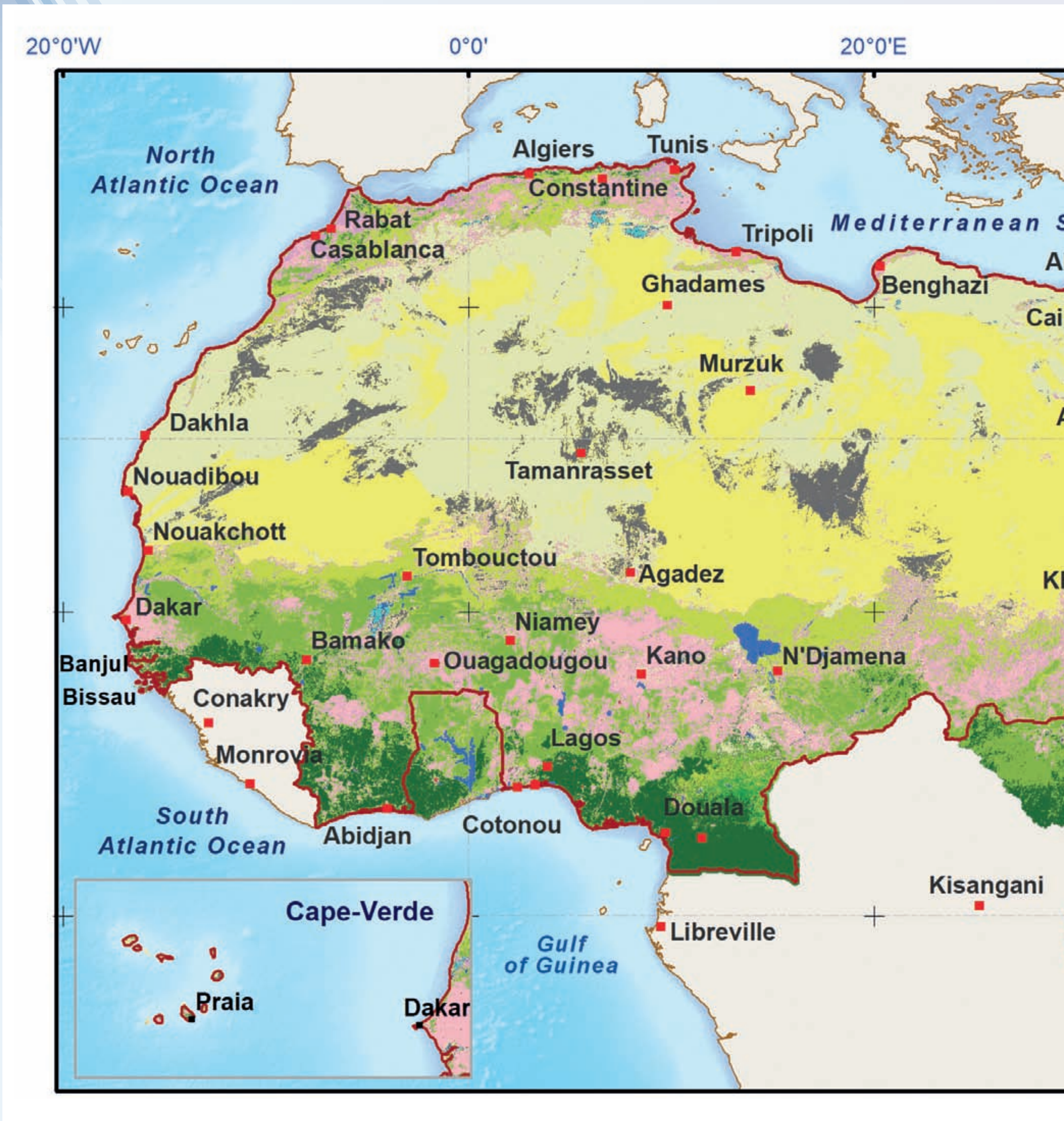
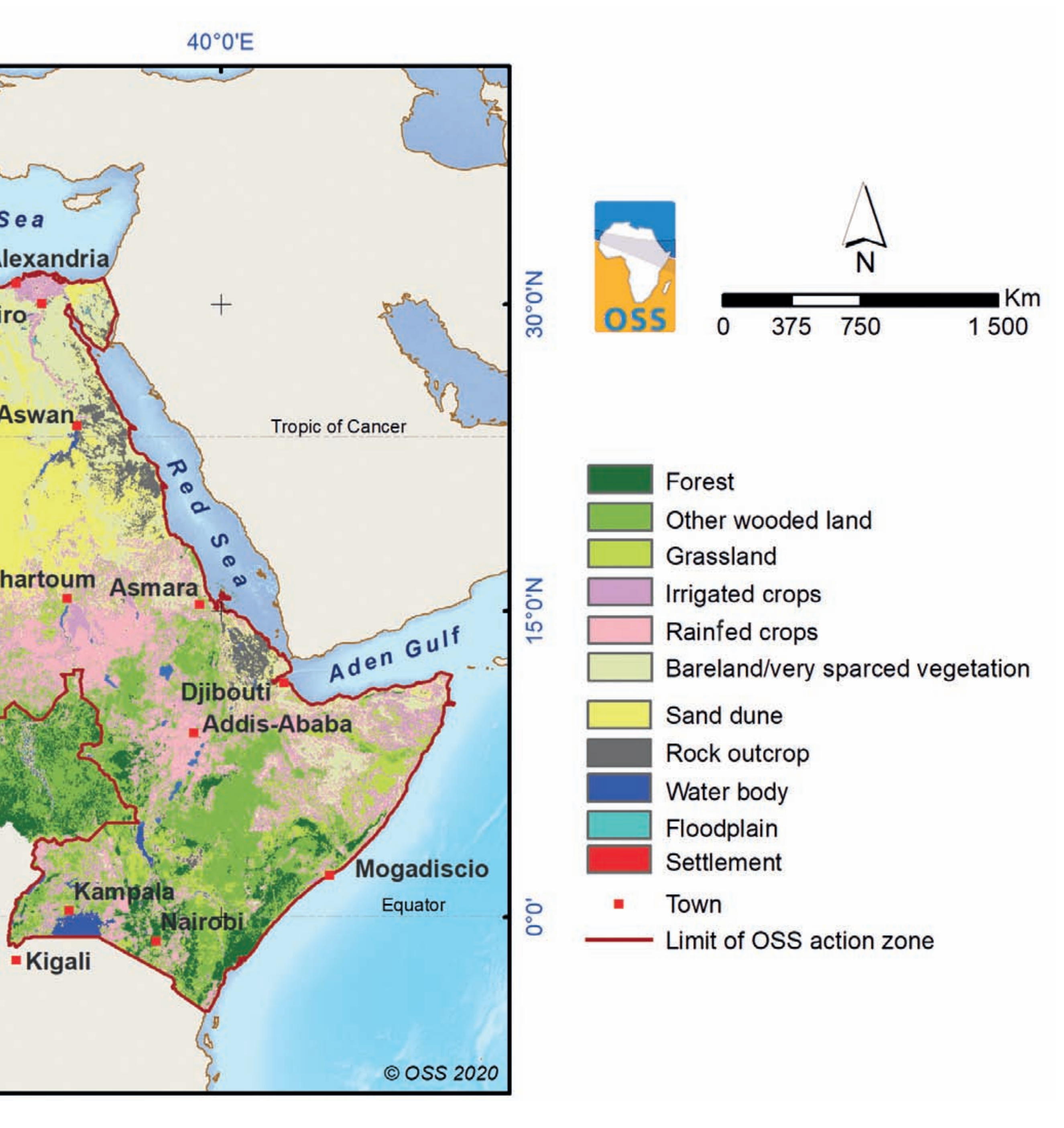


Figure 6. Land use map - *Data source: OSS, 2017*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Forest
Other wooded land
Grassland
Irrigated crops
Rainfed crops
Bareland/very sparced vegetation
Sand dune
Rock outcrop
Water body
Floodplain
Settlement
Town
Limit of OSS action zone

2. WATER RESOURCES IN THE OSS AREA

Oued Sejnane, Tunisia

2. WATER RESOURCES IN THE OSS AREA

2.1 Overview

The OSS area of action has 1,360 billion m^3 of annual renewable water resources[1] **(FAO-Aquastat, 2017)**, unevenly distributed across the regions **(Figure 7)**: 72% for West and Central Africa, 20% for East Africa and 8% for North Africa.

- Most of the ***surface water*** is located in the large transboundary river basins; the most important ones in the area are the *Nile, Niger, Senegal, Lake Chad, and Volta* basins. All the rivers and bodies of water in the area total approximately 1,302 billion m^3/year of renewable water (including a surface water and groundwater common share estimated at 306.42 billion m^3/year). There are nevertheless significant gaps in the spatial distribution of these resources:
  - West and Central Africa: 943 billion m^3/year;
  - East Africa: 268 billion m^3/year;
  - North Africa: 91 billion m^3/year.

- ***Renewable groundwater resources*** total a volume of 364 billion m^3/year, with, as for surface water, an uneven spatial distribution. While the North Africa region has only 4% of the total volume, the East region has 16% and the West plus Central regions have 80%. Moreover, in the OSS area of action, there are significant low-renewable water resources called (fossil resources), not fully exploitable, estimated at approximately 656,000 billion m^3 **(OSS, 2016)**.

Groundwater is located in the aquifers of large sedimentary basins, most of it is shared by several countries and sometimes ***poorly renewed***. Theoretical reserves of the most important shared aquifer systems in the area amount to 590,000 billion m^3, broken down as follows:

- *Nubian Sandstone Aquifer System:* ***500,000 billion m^3****;*
- *North Western Sahara Aquifer System:* ***60,000 billion m^3****;*

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[1] According to the FAO estimation method, Total Renewable Water Resource is: **Renewable Surface Water** + **Renewable** Groundwater - the common share between the two types of resources;

- Surface water: 1,302 billion m^3/year
- Groundwater: 364 billion m^3/year
- Common share: 306.42 billion m^3/year

- *Taoudéni/Tanezrouft Aquifer system:* ***10,000 billion m³****;*
- *Lake Chad Basin Aquifer System:* ***5,800 billion m³****;*
- *Iullemeden Aquifer System:* ***5,000 billion m³****;*
- *Mourzouk Aquifer System (Murzuk):* ***4,800 billion m³****;*
- *Senegal-Mauritania Aquifer System:* ***1,500 billion m³;***
- *Tindouf Aquifer System:* ***800 billion m³****;*
- *Er Rachidia - Béchar Aquifer System:* ***320 billion m³****;*
- *Djeffara Aquifer System:* ***170 billion m³****.*

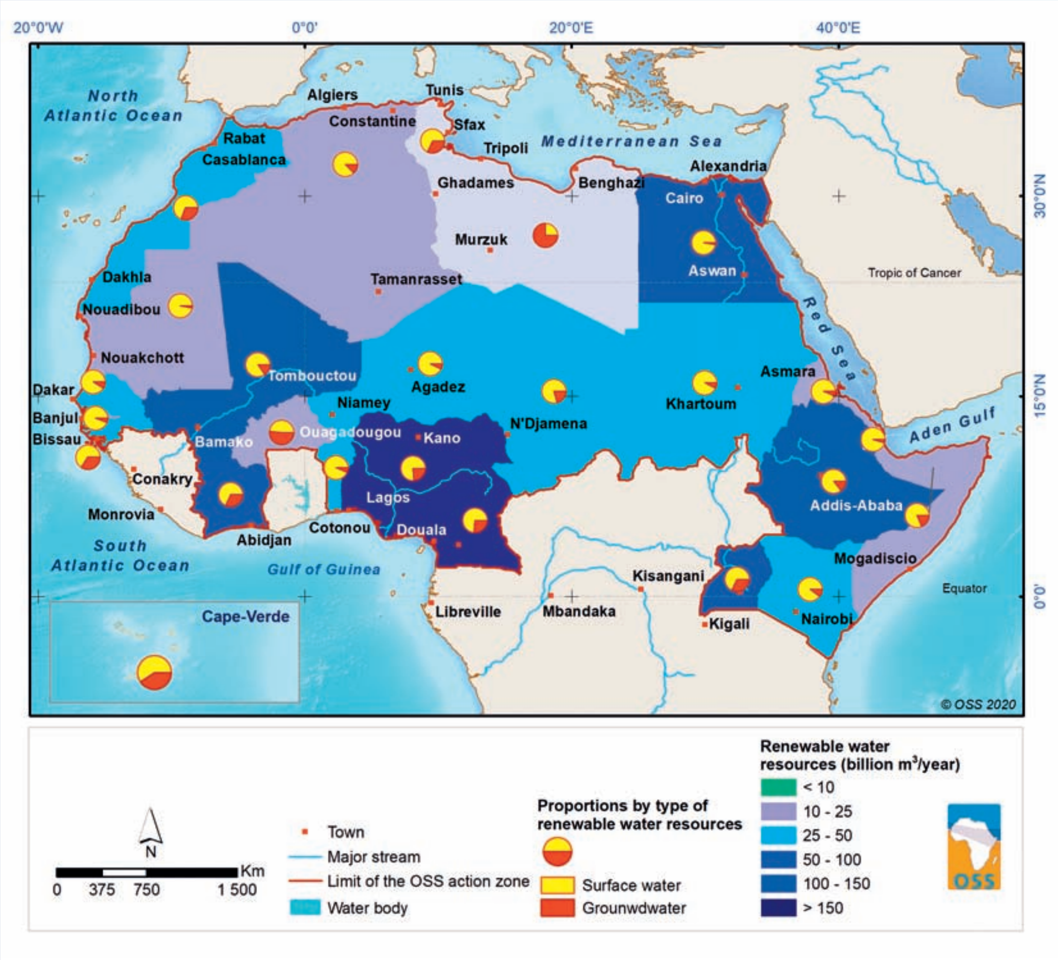

Figure 7. Distribution of renewable water resources - *Data source: FAO-Aquastat, 2019*

The availability of water in the OSS area of action is presented as follows:

- Nearly 60 million people live in countries experiencing water scarcity *(renewable water availability lower than 500 m³/inhab/year)*;
- 258 million people live in countries experiencing water stress *(availability of renewable water between 500 m³/inhab/year and 1,000 m³/inhab/year)*;
- 365 million people live in countries experiencing water vulnerability *(availability of renewable water between 1,000 m³/inhab/year and 1,700 m³/inhab/year)*;
- Nearly 120 million people live in countries experiencing water security or even water comfort *(renewable water availability higher than 1,700 m³/inhab/year)*.

The populations experiencing the most important water scarcity are mainly located in the North African region. There are strong pressures on renewable water resources and this situation could worsen over time.

In terms of renewable water resources exploitation, a huge gap is also registered between the regions:

- The highest average exploitation index is in North Africa with nearly 103% of renewable water resources;
- In East Africa, this index amounts to approximately17%;
- In West and Central Africa, it amounts to 3%.

Irrigation remains the main consumer of water in the OSS area of action *(77%, 74% and 72% respectively for North Africa, East Africa and then West and Central Africa)*.

2.2 Origins and types of water resources

In the OSS area of action, the water resources of a given country can be generated from different origins **(OSS, 1995; OSS, 2001)**, we therefore identify:

- Countries with water resources dominated by ***surface water of internal origin*** associated with a significant share of renewable groundwater. The areas to find this type of water resource are mainly those in the Sahara ancient massifs **(Hoggar, Aïr and Tibesti)** and in the basement areas of the Sahel countries;

- Countries with water resources dominated by *surface water (river and/or lake) with a large share of external origin*. These resources are generally associated with groundwater from the underlying shallow alluvial aquifers. The affected countries strongly depend on the emitting countries located upstream. These are for example Egypt, Mali, Mauritania, Niger, Senegal, Sudan, Chad, etc. These resources are the most sensitive to droughts;

- Countries with water resources consisting mainly of *(hardly renewable or not renewable) fossil groundwater*. These resources constitute the major transboundary sedimentary aquifers. Like the Sahara (Western desert of Egypt, Libya, Algerian and Tunisian Sahara) and the sedimentary Sahara areas of the Sahel countries (Mali, Niger, Sudan, Chad, etc.).

The OSS activities are primarily focused on transboundary water resources in shared aquifers, while taking into account their hydraulic relationships with surface resources.

2.3 Shared water resources

2.3.1 Shared surface water

2.3.1.1 General overview of transboundary water courses and basins

Out of the 263 major transboundary river and lake basins identified worldwide, nearly 80 are located in Africa.

The OSS area of action has more than thirty transboundary river and lake basins **(Figure 8)**, the most important are described below (§ 2.3.1.2).

Hippopotamus pond, Satiri, Burkina Faso

In terms of monitoring and knowledge of these water courses and bodies, it is worth noting that significant efforts need to be made. For example, to this day, basic information, such as the average flows of some of these water courses, remains poorly known.

Table 1 provides basic (and sometimes a little more detailed) information on the most important transboundary water courses and river basins in the OSS area of action, of which only about ten are well informed.

***Figure 8. River-lake basins -** Data source: FAO-Aquastat, 2002*

Table 1. Basic data on the main transboundary basins

Note: The full list of transboundary basins in the OSS area of action is given in *Annex 1*

Basin	Main course length (km)	Average flow at the mouth (m^3/s)	Catchment area (km^2)	Riparian countries (The figures in brackets refer to the sizes of the basin (in km^2) in the country)	Mouth	Basin Organization
Nile	6, 650	2, 830	3, 112, 369	Burundi (13,260), Egypt (326,751), Eritrea (121,890), Ethiopia (365,117), Kenya (46,229), Uganda (231,366), Democratic Republic of Congo (22,143), Sudan (1,978,506), Rwanda (19,876), Tanzania (84,200)	Mediterranean Sea	Nile Basin Initiative (NBI), created in 1999. Headquarters in Entebbe (Uganda).
Niger	4, 184	6, 000	2, 113, 200	Algeria (161,300), Benin (45,300), Burkina Faso (82,900), Cameroon (88,100), Côte d'Ivoire (22,900), Guinea (95,900), Mali (540,700), Niger (497,900), Nigeria (584,193), Chad (16,400)	Atlantic Ocean	Niger Basin Authority (NBA), created in 1963. Headquarters in Niamey (Niger).
Senegal	1, 790	640	436 000	Guinea (30,800), Mauritania (219,100), Mali (150,800), Senegal (35,200)	Atlantic Ocean	Senegal River Basin Development Organization (OMVS), created in 1972. Headquarters in Dakar.
Volta	1, 350	1, 100	412 800	Benin (15,000), Burkina Faso (173,500), Côte d'Ivoire (135,00), Ghana (166,000), Togo (25,800), Mali (18,800)	Atlantic Ocean	Volta Basin Authority (VBA), created in 2007. Headquarters in Ouagadougou (Burkina Faso).
Comoé	759	106	78 100	Burkina Faso (16,900), Côte d'Ivoire (58,300), Ghana (2,200), Mali (700)	Atlantic Ocean	
Gambia	1, 130	149	69 900	Gambia (5,900), Guinea (13,200), Senegal (50,700)	Atlantic Ocean	Gambia River Basin Development Organization (OMVG), created in 1967. Headquarters in Dakar.
Sassandra	840	550	68 200	Ivory Coast (59,800), Guinea (8,400)	Atlantic Ocean	
Lake Chad	NA	NA	Topographic basin: **2,381,635 km^2** theoretically but the active or conventional basin is only **967,000 km^2**	Cameroon, Central African Republic, Libya, Niger, Nigeria, Chad	Endorheic lake	Lake Chad Basin Commission (LCBC), created in 1964. Headquarters in Ndjamena (Chad).

Data source: Hissel, 2013

2.3.1.2 Characteristics of the main transboundary river basins

■ Nile basin

The Nile, with a total length of 6,650 km and an average flow rate of 2,830 m^3/s, is the second longest river in the world after the Amazon. Its basin area covers more than 3 million km^2 **(Figure 9)**. It is formed by the junction in Khartoum (Sudan), of the Blue Nile and the White Nile.

The White Nile has its source in Lake Victoria, while the source of the Blue Nile is located at Lake Tana (or Tsana) in Ethiopia. Its mouth is located in Egypt, where it forms a delta (Nile Delta) before emptying into the Mediterranean Sea. The Nile river basin is shared by 11 countries: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Uganda, Democratic Republic of Congo (DRC), Rwanda, Sudan, South Sudan and Tanzania.

The Nile basin is highly important for the socio-economic development of its 257 million inhabitants (approximately 20% of the continent's population). Several development projects depending on the water resources of the Nile are being implemented in different economic sectors, in particular agriculture, energy, fishing, tourism.

Current water withdrawals from the Nile are estimated at approximately 100 billion m^3/year, 85% is used for agriculture and 15% for other purposes ***(NBI, 2016)***. There are currently around twenty large dams in the basin, most of them are multi-purpose, such as those of Aswan *high Dam* in Egypt (162 billion m^3 with about 31 billion m^3 of dead volume), *Grand Ethiopian Renaissance Dam* (GERD) in Ethiopia (74 billion m^3)[2] and *Merowe Dam* in Sudan (12.5 billion m^3).

The natural resources of the Nile Basin lie under significant pressure mainly generated by agriculture, the spread of invasive aquatic plant species, bush fires, mining, urbanization and climate change. These difficulties are exacerbated by demographic pressure, poverty and insecurity.

The basin managing body is the ***Nile Basin Initiative (NBI)***, established in 1999 and currently headquartered in Entebbe, Uganda. The purpose of the Initiative is to strengthen cooperation between basin States for sustainable economic development through the fair use of water resources.

[2] GERD: Under construction in Ethiopia

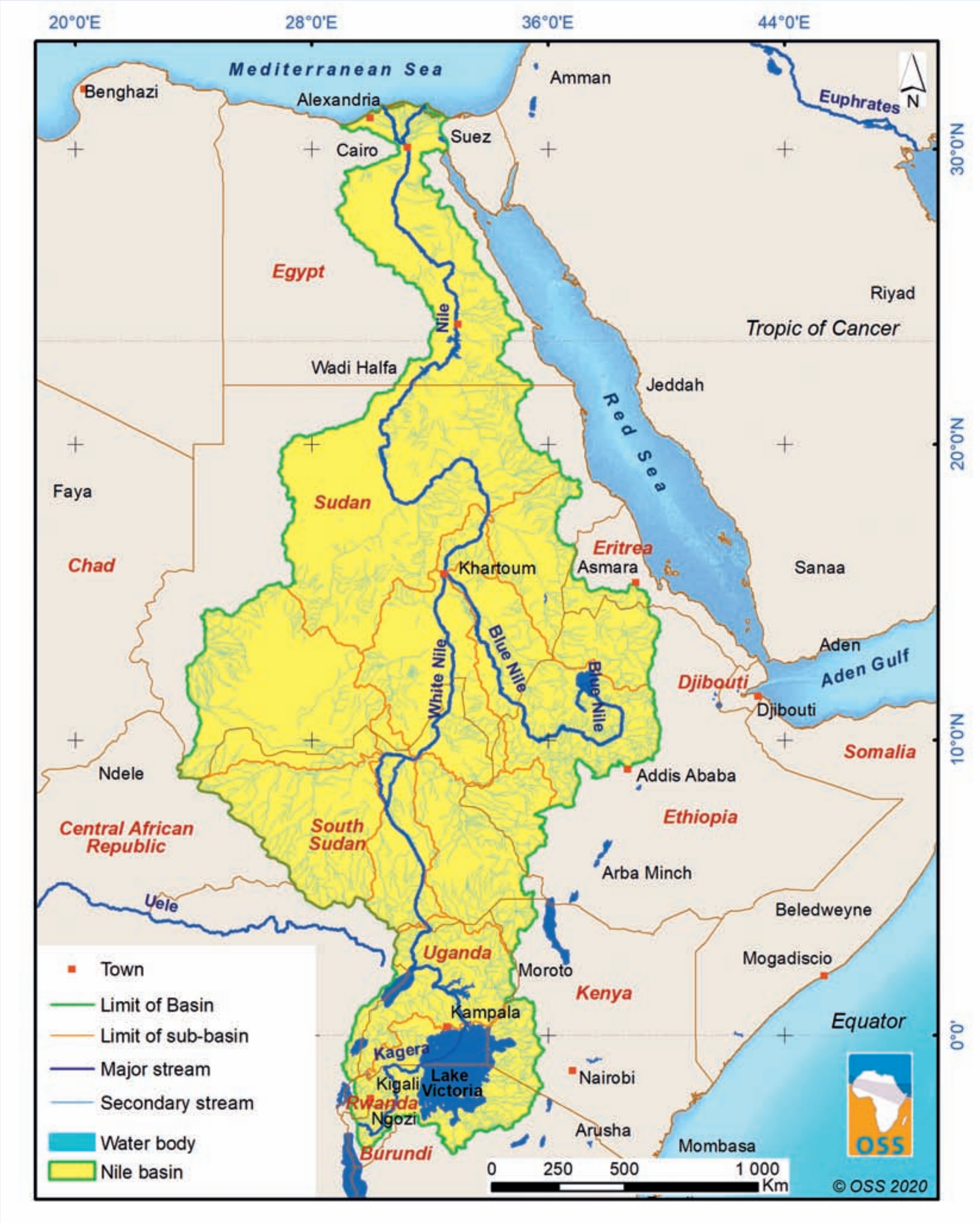

Figure 9. Limits and hydrography of the Nile basin - *Data source: FAO-Aquastat, 2011*

▪ Niger river basin

The Niger river, approximately 4,200 km long, drains a river basin of more than 2.2 million km^2 **(Figure 10)**, including approximately 1.5 million km^2 of active river basin spread over nine countries (Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Guinea, Mali, Niger, Nigeria and Chad)[3] *(NBA, 2007)*.

The river has its source in the Fouta-Djalon massif in Guinea and its mouth is located in Nigeria where it forms a delta (Niger Delta) before emptying into the Atlantic Ocean. From its source to its mouth, it crosses the Sahel and sub-desert regions, where it loses a significant part of its water supply (25 to 50%), mainly by evaporation.

The river basin encompasses several climate zones and can be divided into four distinct hydro-geographic subsystems: *Upper Niger, Inner Delta, Middle Niger and Lower Niger.*

The average annual discharge of the river during the 2015/2016 season are presented, from upstream to downstream, as follows: 1,002 m^3/s at Koulikoro (Mali) in Upper Niger, 1,973 m^3/s at Diré (Mali) in the Inner Delta, 958 m^3/s in the downstream Delta and 6,054 m^3/s in Lokoja (Nigeria) in the Lower Niger.

About ten large multi-purpose dams contribute to the regulation of river water and the development of economic activities (particularly agriculture) in the basin and in the riparian countries. The most important dams in the basin are established in the Malian part (the dams of Sélingué, Sotuba, Markala, etc.) and the Nigerian part (the dams of Kaindji, Shiroro, Zungeru, Jebba, etc.).

The achievement of other important dams is also planned. The total volume mobilized by all the dams in the basin amounts to 42 billion m^3, with approximately 1.8 million hectares fitted for irrigation and 2,000 MW of installed hydroelectric capacity *(NBA, 2013)*.

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[3] Algeria is connected to the basin by short-lived rivers which sometimes contribute in small proportions to the flow towards the drainage system of the Niger River.

The Niger basin faces some problems *(NBA, 2013)*:

- Environmental and ecological problems: climate change, soil degradation, deforestation, overexploitation of fishery resources, pollution by domestic and industrial discharges and particularly by oil activities in the Maritime Delta (in Nigeria);

- Economic problems: the weakness and lack of socio-economic infrastructures and equipment which has a consequence of increasing poverty of the basin populations.

The Niger Basin Authority (NBA) is the intergovernmental body responsible for the coordinated and consolidated management of the basin's resources. Created in 1964, the NBA, headquartered in Niamey (Niger), includes the 9 member States sharing the basin and Algeria as an observer member.

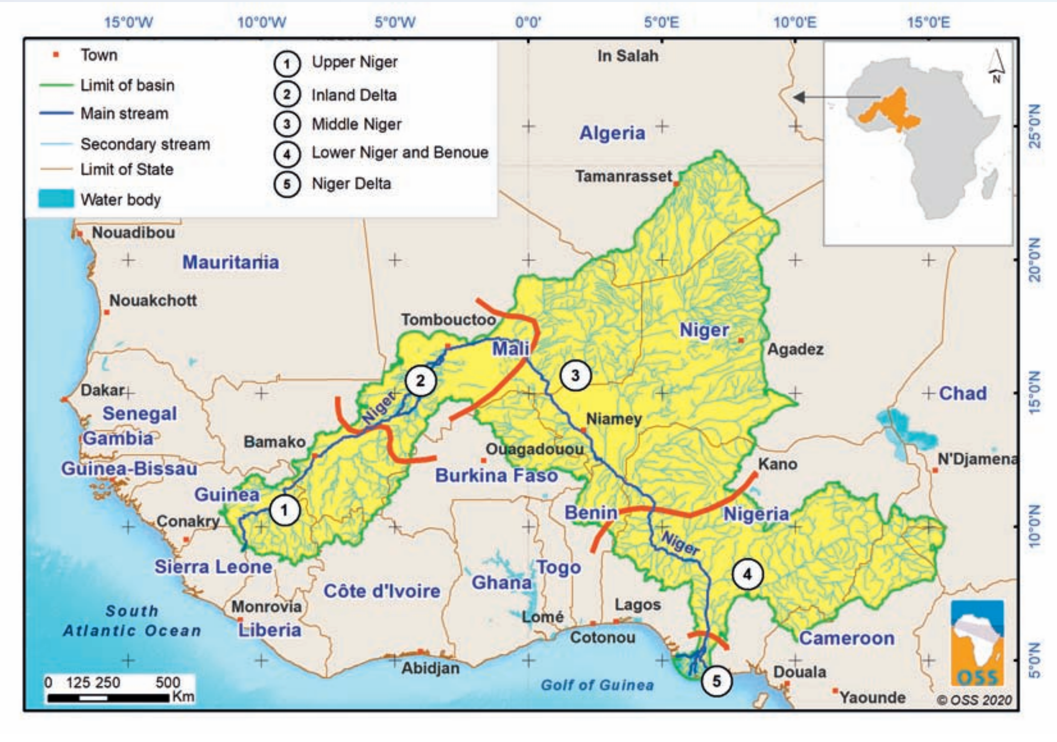

Figure 10. Limits and hydrography of the Niger river basin - *Data source: FAO-Aquastat, 2009*

■ Senegal river basin

The Senegal River, approximately 1,800 km long with 690 m^3/s average flow, is fed by an approximately 436,000 km^2 catchment, shared by 4 countries: Guinea-Conakry, Mali, Mauritania and Senegal **(Figure 11)**. The three main tributaries of the Senegal River (the Bafing, the Bakoye and the Falémé) have their source in the Fouta-Djalon Massif (Republic of Guinea). The Bafing drains most of the river's water (around 60%).

Large water dams, such as the Manantali (11.5 billion m^3) and Diama (250 million m^3) dams, shared properties of the four riparian countries of the basin, help meet part of their needs in electricity as well as significant agricultural production.

The main transboundary environmental and ecological problems in the basin are land degradation, bush fires, alteration of wetlands and change of estuarine hydrodynamics, degradation of ichthyologic fauna, as well as changes in the availability of surface water. In addition to these problems, there is also the massive presence of invasive aquatic species (Typha in particular), led by the two large dams and the irrigated perimeters which have changed the hydrological regime and the quality of the river's water.

Water body in Rosso region, Mauritania»

Water management in the Senegal River is the responsibility of the Organization for the Development of the Senegal River (OMVS), an intergovernmental body based in Dakar (Senegal) set up in 1972 by three of the four States (Mali, Mauritania, Senegal)) sharing the resources of the basin. Guinea joined the Organization in 2006. It has three objectives: the development of irrigated agriculture, energy production and navigation. The OMVS currently provides the Technical Secretariat for the African Network of Basin Organizations (ANBO).

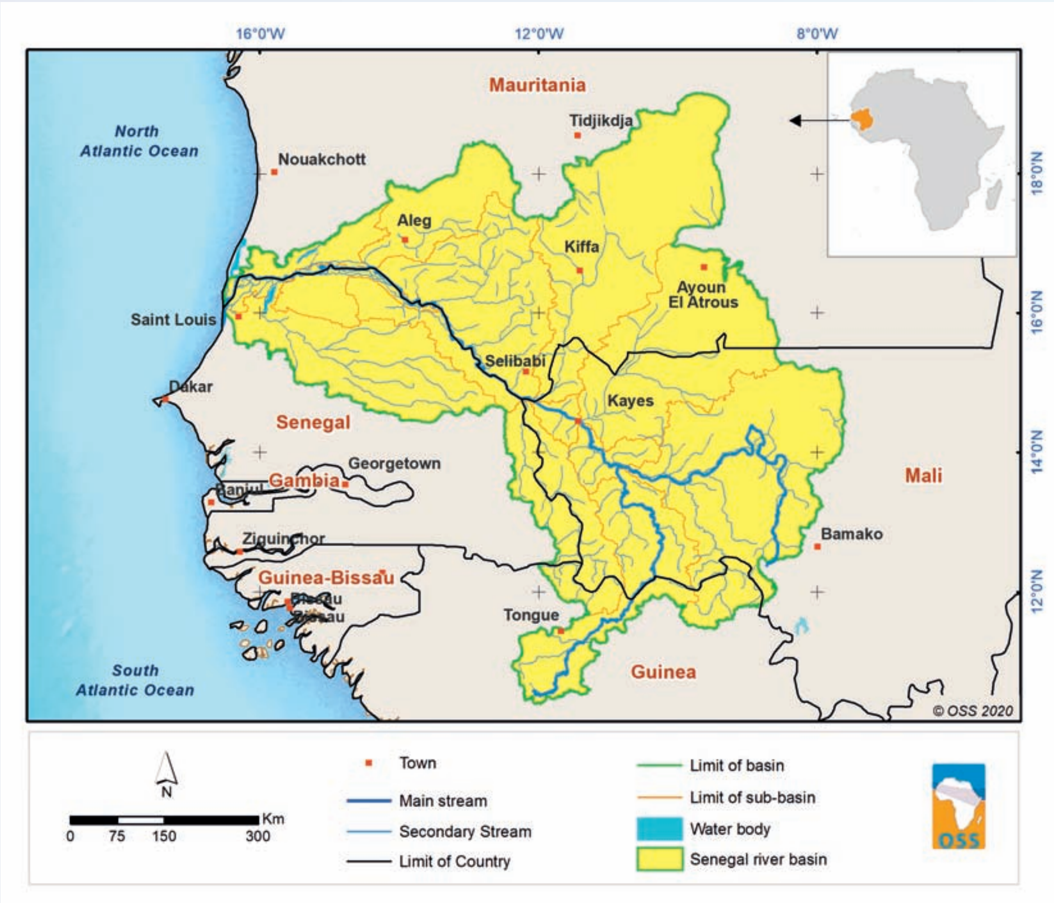

***Figure 11.* Limits and hydrography of the Senegal river basin** - *Data source: FAO-Aquastat, 2009*

▪ Volta Basin

The Volta is approximately 1,350 km long, with an approximately 400,000 km^2 catchment shared by six (06) countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo **(Figure 12)**. It has a 1,100 m^3/s average flow rate at its mouth. The Volta basin has four (04) sub-basins, the main tributaries of which are: the Mouhoun (the Black Volta), the Nakambé (the White Volta), the Oti river (which has its source in Benin named Pendjari and crosses Togo before joining the Volta in Ghana), the lower Volta (made up of small rivers that empty directly into the Akosombo Dam also called Lake Volta, in Ghana). Burkina Faso and Ghana include the largest proportions of the basin, respectively 43% and 42%.

Several dams have been built for irrigation water, hydroelectricity and domestic uses. The largest structure is the Akosombo hydroelectric dam in Ghana (8,700 km^2, 148,000 million m^3 and 1,020 MW). The other major dams in the basin are: Kompienga (2,025 million m^3 and 14 MW), Bagré (1,700 million m^3 and 16 MW), Bui (12,570 million m^3 and 400 MW), Kpong (12,350 million m^3 and 400 MW). A new dam built at Samandeni (1,050 million m^3 and 16 GWh) on the Black Volta in Burkina Faso and mainly intended for the production of electricity, was inaugurated in 2019.

The dams (with both agricultural and hydroelectric vocation) mobilize some 2,900 million m^3 and irrigate nearly 30,500 ha. In addition to these large dams, there are also many small dams with a total storage capacity of approximately 230 million m^3 ***(Liebe et al., 2005; De Condappa et al., 2009; McCartney et al., 2012)***.

The transboundary environmental problems registered in the basin are mainly the decrease in flows, which results in the long-lasting drying up of several tributaries, coastal erosion, with the degradation of the ecosystems around the river mouth, the invasion of aquatic plants *(water hyacinth, water lettuce, mimosa, papyrus, etc.)*, deforestation and soil degradation, sedimentation in watercourses, degradation of the water quality, due to the intensive use of nitrate and phosphate fertilizers.

In 2007, the 6 States sharing the basin set up the Volta Basin Authority (VBA) that aims at promoting Integrated Water Resources Management (IWRM) and permanent consultation tools between stakeholders and the development of water resources development infrastructure. The VBA is headquartered in Ouagadougou in Burkina Faso.

Wetland, Togo

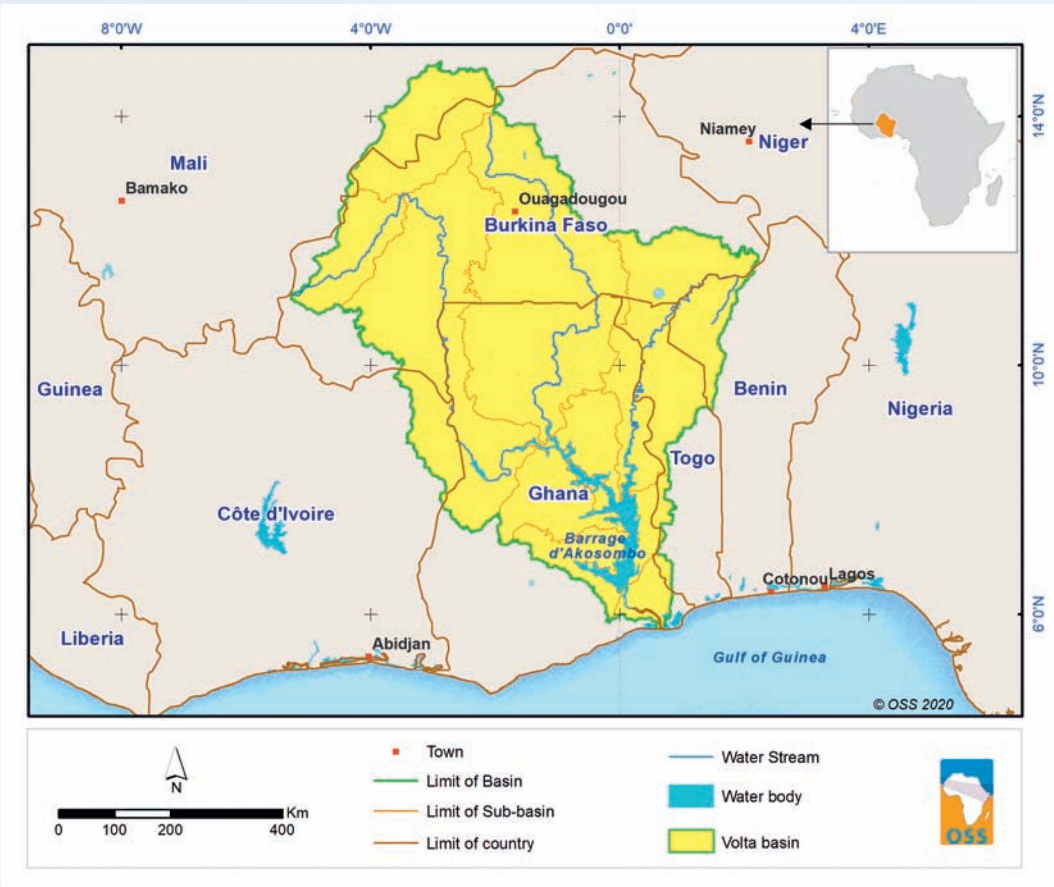

Figure 12. Limits and hydrography of the Volta basin - *Data source: FAO-Aquastat, 2009*

■ Lake Chad basin

Lake Chad **(Figure 13)**, located in the northern part of central Africa, is made up of a large shallow and closed basin of fresh water (endorheic basin, with no outlet to the sea). The area of its ***topographic basin*** is approximately 2,400,000 km² and extends mainly over Algeria, Cameroon, Libya, Niger, Nigeria, Central African Republic (CAR), Sudan and Chad. Almost the entire topographic basin located in the Sahara zone to the north, does not bring surface water to the lake. The hydrologically active part of the basin is referred to as the ***"conventional basin"*** or ***"active basin"*** and extends over 5 countries: Cameroon, Central African Republic, Niger, Nigeria and Chad, with an area of approximately 967,000 km². The surface area of the lake, which reached 25,000 km² before 1973, has significantly shrunk over time and now stands at approximately 2,000 km² (more than 90% reduction).

The lake is mainly supplied (for nearly 95% of the inflow) by the *Chari* (having its source in the mountainous areas in the Central African Republic) and the *Logone* (tributary of the Chari having its source in Chad); the remaining 5% are supplied by the *Komadougou-Yobé* (source in Nigeria), the *El Beïd* and various small rivers from Nigeria and Cameroon as well as by immediate rain. The *Chari-Logone* complex catchment is approximately 600,000 km² and that of the *Komadougou-Yobe* extends over 148,000 km² ***(Olivry et al. 1996; Lemoalle, 2014)***.

Lake Chad and its ecosystems have a tremendous strategic interest to the region. They provide water and other means of subsistence for more than 30 million people who mostly live from agriculture, livestock and fishing.

The main transboundary problems of the basin are:

- The very high variability of the hydrological and hydrogeological regime, resulting in a drastic reduction in the lake surface,
- The degradation of biodiversity, sedimentation and the climate change impacts (cross-cutting problem).

The security situation in the basin is an additional transboundary problem and «threat multiplier», thus contributing to intensify other transboundary problems.

The Lake Chad Basin Commission (LCBC) was created in 1964 and includes 6 riparian States (Cameroon, Central African Republic, Libya, Niger, Nigeria and Chad) to promote regional cooperation and equitable and sustainable management of the basin's resources, conservation and protection of its ecosystems as well as the promotion of peace and security in the region. This mission covers both surface water and groundwater management. The LCBC is headquartered in N'Djamena in Chad.

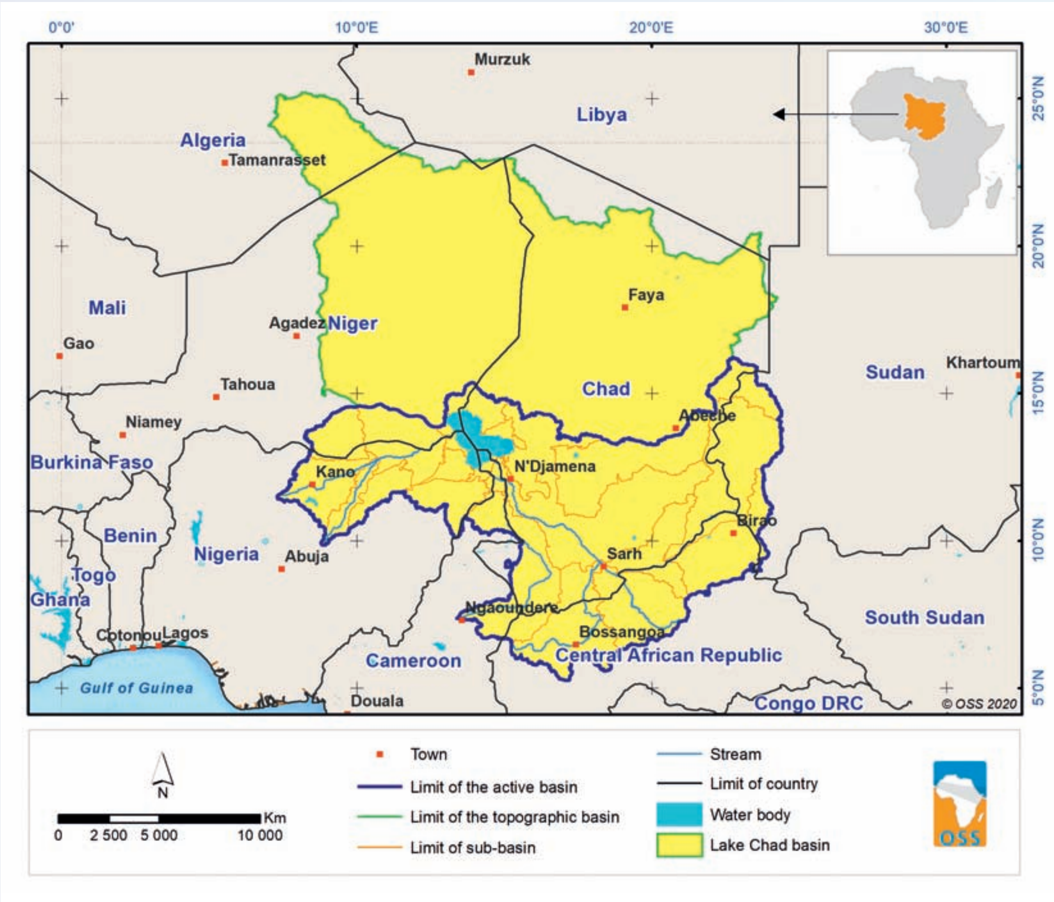

Figure 13. Limits and hydrography of the Lake Chad basin - *Data source: FAO-Aquastat, 2009*

2.3.2 Shared groundwater

2.3.2.1. Overview of the main shared aquifers

Worldwide, some 608 transboundary aquifers (shared by two or more countries) have been identified, including 83 in Africa **(IGRAC et al, 2015)**. In the OSS area of action, nearly forty transboundary aquifers were identified during a recent survey (TWAP 2015 Project, GEF/UNESCO with the OSS contribution) **(Table 2)**. Among them, only ten are more or less documented **(Figure 14)**. These are the following aquifer systems, in order of their surface area:

- *Nubian Sandstone (Egypt, Libya, Sudan, Chad);*
- *Iullemeden (Mali, Niger, Nigeria) - Taoudéni / Tanezrouft (Algeria, Benin, Burkina Faso, Mali, Mauritania);*
- *Lake Chad (Cameroon, Libya, Niger, Nigeria, CAR, Chad);*
- *North Western Sahara (Algeria, Libya, Tunisia);*
- *Mourzouk (Algeria, Libya, Niger);*
- *Senegal-Mauritania (Gambia, Guinea-Bissau, Mauritania, Senegal);*
- *Tindouf (Algeria, Morocco, Mauritania);*
- *Djeffara (Libya, Tunisia);*
- *Er Rachidia-Béchar (Algeria, Morocco).*

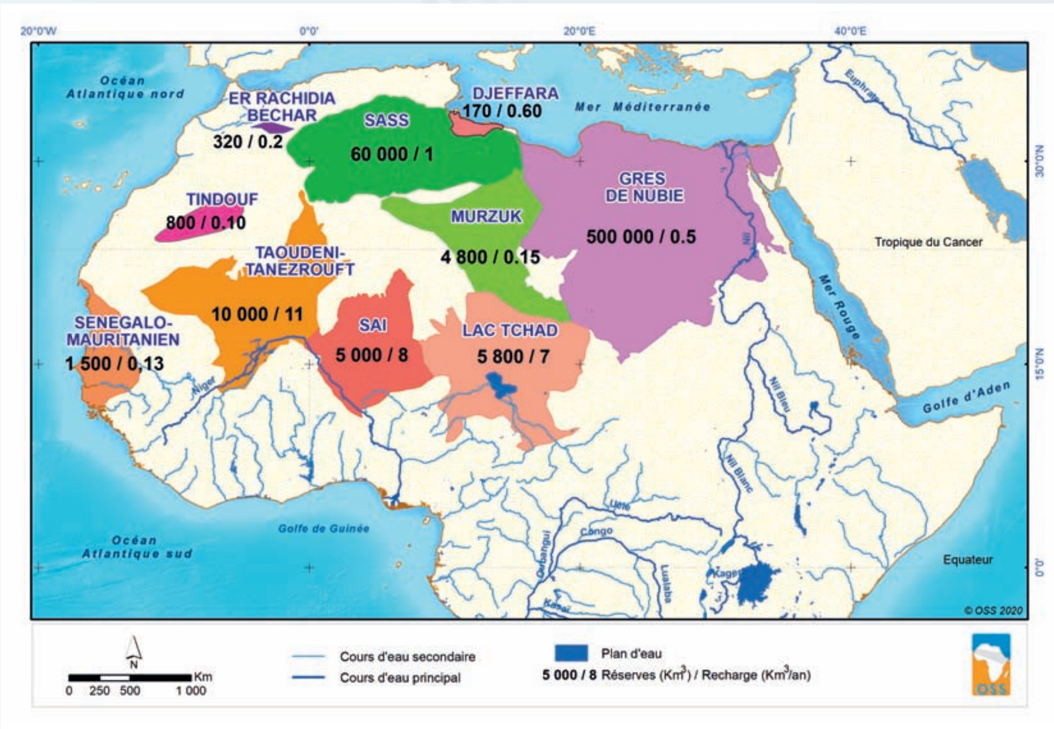

Figure 14. The main aquifer systems: reserves and recharge *- Data source: OSS, 2018*

Table 2. Data on the main transboundary aquifer systems

Note: The full list of transboundary aquifers in the OSS area of action is given in *Annex 2*

N°	Aquifer name	Countries concerned	Area [Km²]	Reserves [Billions m³]	Resources [Billions m³]
1	Nubian Sandstone Aquifer System	Egypt, Libya, Sudan, Chad	2, 000,000	500,000	0,5
2	Taoudéni / Tanezrouft aquifer **	Algeria, Burkina Faso, Mali, Mauritania, Niger	2, 000,000	10,000	11
3	Lake Chad Basin Aquifer	Algeria, Cameroon, Central African Republic, Libya, Niger, Nigeria, Chad	1, 900,000	5,800	7
4	North Western Sahara Aquifer System	Algeria, Libya, Tunisia	1, 000,000	60,000	1
5	Karoo-carbonaté aquifer	Central African Republic, Democratic Republic of Congo, South Sudan	941,100		
6	Iullemeden aquifer **	Algeria, Benin, Burkina Faso, Mali, Niger, Nigeria	500,000	5,000	8
7	Mourzouk aquifer	Algeria, Libya, Niger	450,000	4,800	0,15
8	Al Sudd basin (Bahr al Jabal) Aquifer	Ethiopia, Kenya, South Sudan	370,648		
9	Senegal-Mauritania Aquifer System	Gambia, Guinea-Bissau, Mauritania, Senegal	300,000	1,500	0,13
10	Tindouf Aquifer System	Algeria, Morocco, Mauritania	221,019	800	0,103
11	Bénoué Valley Aquifer	Cameroon, Nigeria	219,001		
12	Baggara Basin	CAR, South Sudan, Sudan	213,600		
13	Volta Basin	Benin, Burkina Faso, Ghana, Niger, Togo	130,000		
14	Afar Rift Valley/Afar Triangle Aquifer	Djibouti, Eritrea, Ethiopia	51,000		
15	Gedaref aquifer	Eritrea, Ethiopia, Sudan	51,000		
16	Rift Aquifer	Democratic Republic of Congo, Uganda, South Sudan	44,632		
17	Djeffara Aquifer System	Libya, Tunisia	43,000	170	0,6

Data source: OSS and IGRAC 2015

*** The two aquifers are connected by the Gao ditch or «Gao Strait» and thus form a single System, the Iullemeden Taoudeni/Tanezrouft Aquifer System (ITTAS).*

2.3.2.2. Characteristics of the main transboundary aquifers

▪ Nubian Sandstone Aquifer (NSAS): Egypt, Libya, Sudan and Chad

The Nubian sandstone aquifer ***(Figure 15)***, that extends over almost 2.2 million km², is one of the largest transboundary and fossil aquifer systems in the world. It is shared by Egypt (828,000 km²), Libya (760,000 km²), Sudan (376,000 km²) and Chad (235,000 km²). The system consists of two levels of overlapping aquifers: the Nubian sandstone aquifer, topped in its downstream part by the post-Nubian aquifer.

The thickness of the aquifer varies from a hundred meters (in its southern part in Sudan and Chad) to nearly 5,000 m (in the Libyan and Egyptian parts). The volume of stored water amounts to 500,000 billion m^3 ***(IAEA, GEF, 2013)***[4]. All this reserve is fossil with almost zero recharge under current climate conditions. The water quality is suitable over most of its extension except in a small part of the post-Nubian aquifer, in the northern part of the basin, next to the Mediterranean, where salinity is quite high ***(UNESCO and OSS, 2005)***.

Most of the aquifer resources are currently exploited by Egypt and Libya. Annual withdrawals from the basin were estimated in 2002 at approximately 2.3 billion m^3 (1 billion m^3 in Egypt, 0.9 billion m^3 in Libya, 0.4 billion m^3 in Sudan and insignificant in Chad) ***(CEDARE, 2001)***. In 2012, a new estimate ***(CEDARE, 2012)*** showed that annual withdrawals reached some 2.4 billion m^3 in Egypt and 1.5 billion m^3 in Libya[5].


Market garden crops Adrar, Algeria and Chad

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[4] Regional Strategic Action Programme for the Nubian Aquifer System, developed in 2013. 95p.

[5] In Libya, withdrawals are made under the "Great Man Made River" program for the transfer of water from this aquifer to the coastal part of Libya, in order to ensure the agricultural development of these regions as well as drinking water.

In order to better organize the aquifer system management, the four countries have set up, since 1991, an intergovernmental body called *«Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System»* established in Tripoli (Libya). A Strategic Action Plan (SAP) was developed for the aquifer system in 2013, with funding from GEF and technical support from IAEA.

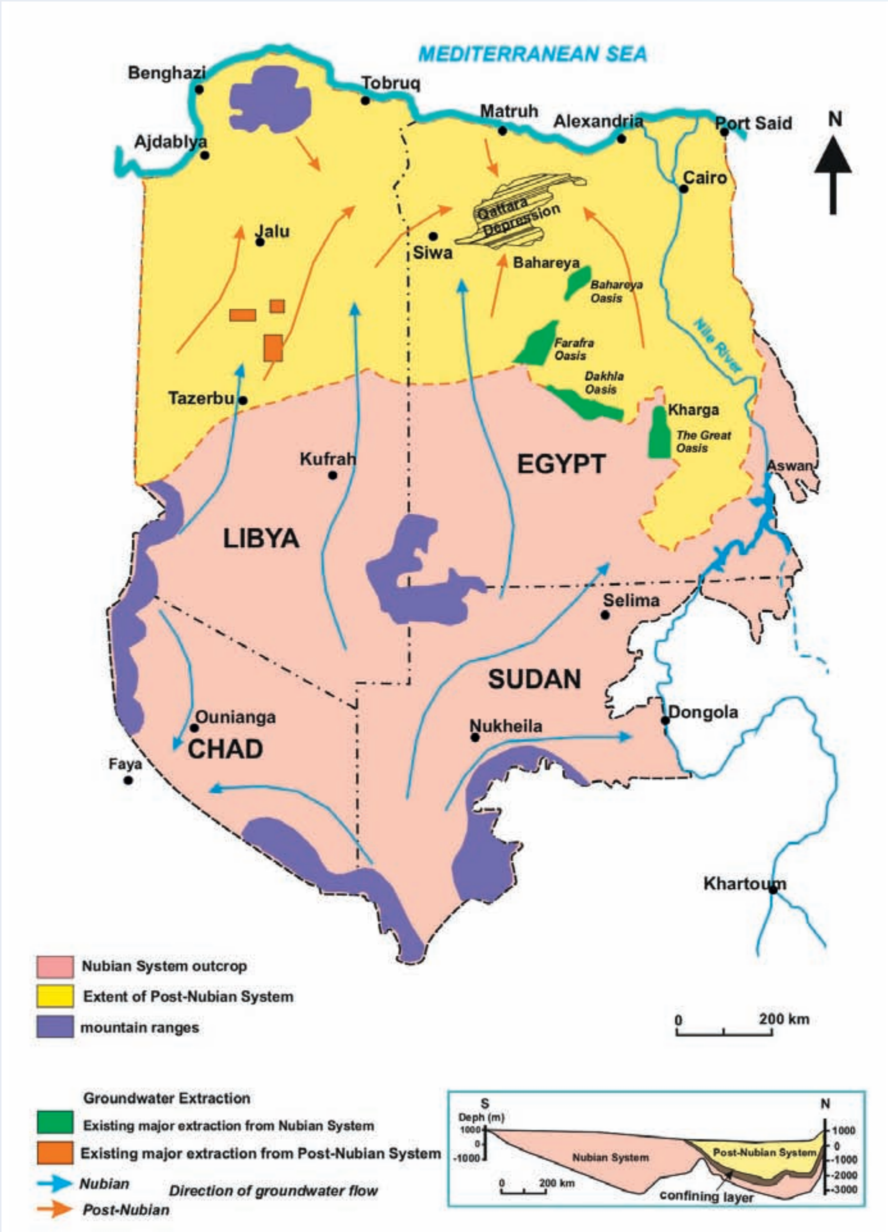

Figure 15. ***Hydrogeological framework of the Nubian Sandstone Aquifer System -*** *Data source: UNESCO/IHP-VI 2006 (modified)*

▪ North Western Sahara Aquifer System (NWSAS): Algeria, Libya, Tunisia

The North Western Sahara Aquifer System (NWSAS), which covers an approximately 1 million km^2 area, is shared by Algeria (700,000 km^2), Libya (250,000 km^2) and Tunisia (80,000 km^2). km^2) **(Figure 16)**.

This aquifer system has two main deep water tables, the Continental Intercalaire (CI) formation, topped by that of the Complexe Terminal (CT), and contains significant reserves of low-renewable water, estimated at nearly 60,000 billion m^3. The average recharge of the aquifer is estimated at 1 billion m^3/year.

The exploitation of these water tables has significantly evolved over the past seven decades. Annual withdrawals, estimated at 0.6 billion m^3 in 1950, reached about 3 billion m^3 in 2018 (OSS, 2019) and are distributed as follows: 2.19 billion m^3 in Algeria, 0.52 billion m^3 in Tunisia and 0.30 billion m^3 in Libya. NWSAS waters lie under the risk of salinization.

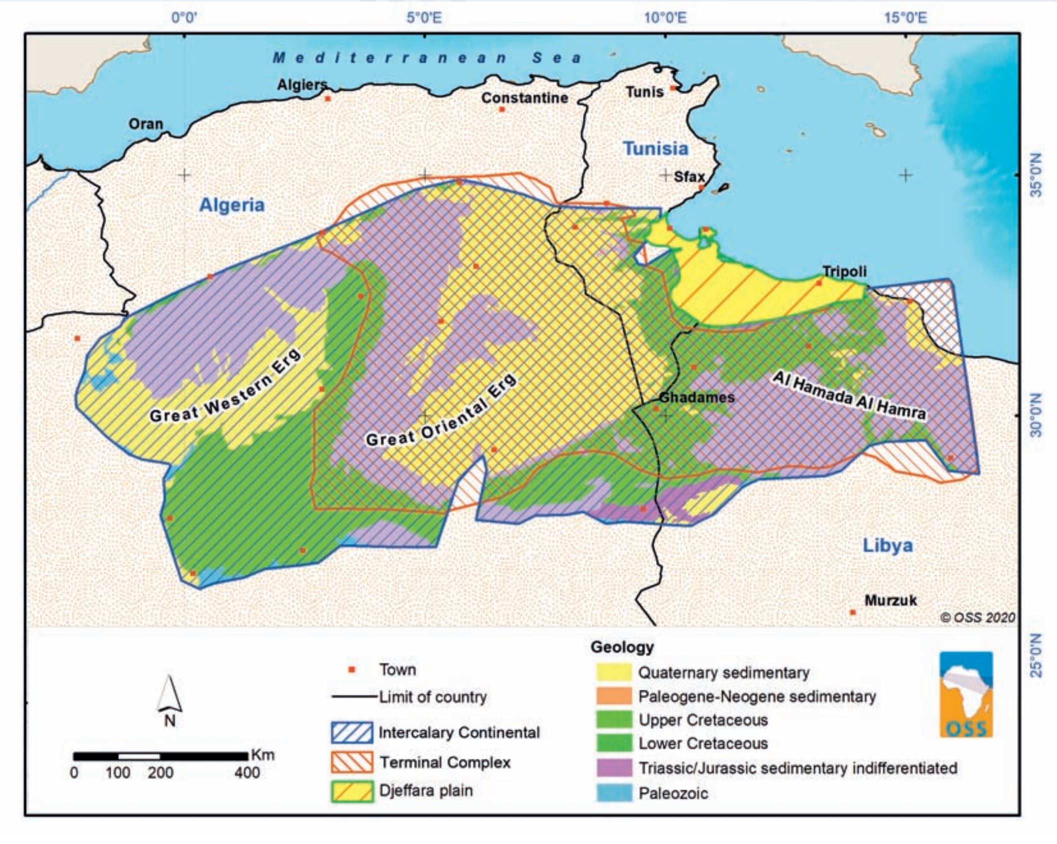

Figure 16. ***Geographic and geological framework of the North Western Sahara Aquifer System -*** *Data source: OSS, 2012*

Aware of the risks of overexploitation and the economic and environmental constraints, the three countries launched, by the end of the 1990s, a major program of studies that mainly aims to enable a consultation-based exploitation. This program, better known as the «NWSAS Project», was conducted by the OSS from 1999 to 2015.

In 2008, the approach led to the establishment of a Consultation Mechanism, whose technical coordination unit is based at the OSS headquarters in Tunis (Tunisia).

Rational irrigation in an oasis, Adrar, Algeria

▪ Djeffara Aquifer System: Libya, Tunisia

This aquifer system **(Figure 17)**, located in the Tunisian-Libyan coastal plain, covers a nearly 43,000 km^2 area, shared by Libya (21,000 km^2) and Tunisia (22,000 km^2)[6]. There is a hydrogeological link between the Djeffara aquifer and the NWSAS one: waters of the *"Intercalairy Continental (CI)"* of the NWSAS partly feed the Djeffara in its Tunisian part.

[6] The Djeffara aquifer system has been the subject of hydraulic studies concurrent with the North Western Sahara aquifer system. The established cooperation also covers the plain of Djeffara..

The Djeffara region is highly important for Libya because it is home to half of its population, just as it is home, in its Tunisian part, to nearly one tenth of the country's population and key economic activities such as tourism, Gabès' chemical industries and agriculture. The aquifer system has experienced intense exploitation linked to demographic growth and socio-economic development in the region.

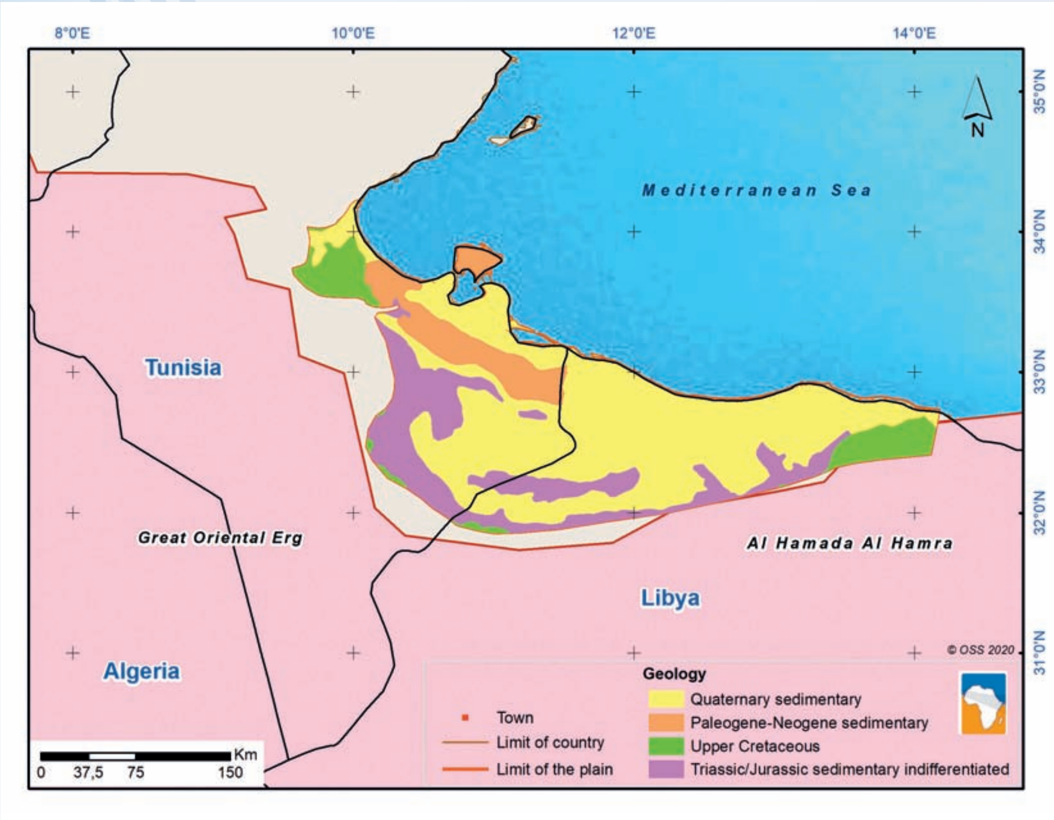

Figure 17. ***Geographic and geological framework of the Djeffara Aquifer System*** - *Data source: OSS, 2012*

The hydrogeological study of the Djeffara aquifer system, carried out by the OSS, in close collaboration with the two affected countries (Libya and Tunisia), made it possible to fine-tune the knowledge on the hydrogeological functioning of the aquifer system and to highlight the risks of overexploitation, generalized drop in piezometric level, salt intrusion and general deterioration of water quality.

Water reserves are estimated at 170 billion m^3. In four decades, withdrawals have increased from 200 million m^3 in 1960 to nearly 1.4 billion m^3 in 2003 (with drawdowns greater than 50 m in the coastal zone), while recharge amounts to 600 million m^3/year (OSS, 2005).

Hot water cooler in the old Kebili oasis, Tunisia

▪ Iullemeden - Taoudéni/Tanezrouft Aquifer System

The Iullemeden-Taoudéni/Tanezrouft Aquifer System (ITTAS) **(Figure 18)** covers an approximately 2 million km^2 area and extends over seven countries: Algeria (17%), Benin (2%), Burkina Faso (5%), Mali (41%), Mauritania (10%), Niger (20%) and Nigeria (5%).

The ITTAS is a unique system, made up of the Iullemeden Aquifer System (IAS) in its eastern part (500,000 km^2) and the Taoudéni/Tanezrouft Aquifer System (TTAS) in the western part (1,500,000 km^2). These two systems are connected by a strait called the «Gao Ditch» or the «Gao Strait». They are characterized by two main water tables: the Intercalary Continental at the base and the Terminal Continental at the top.

The Niger river runs through the ITTAS over nearly 2,500 km and supplies aquifers with more than 1.5 billion m^3/year in the Taoudéni-Tanezrouft basin, while it receives around 3.3 billion m^3/year downstream in the Iullemeden basin.

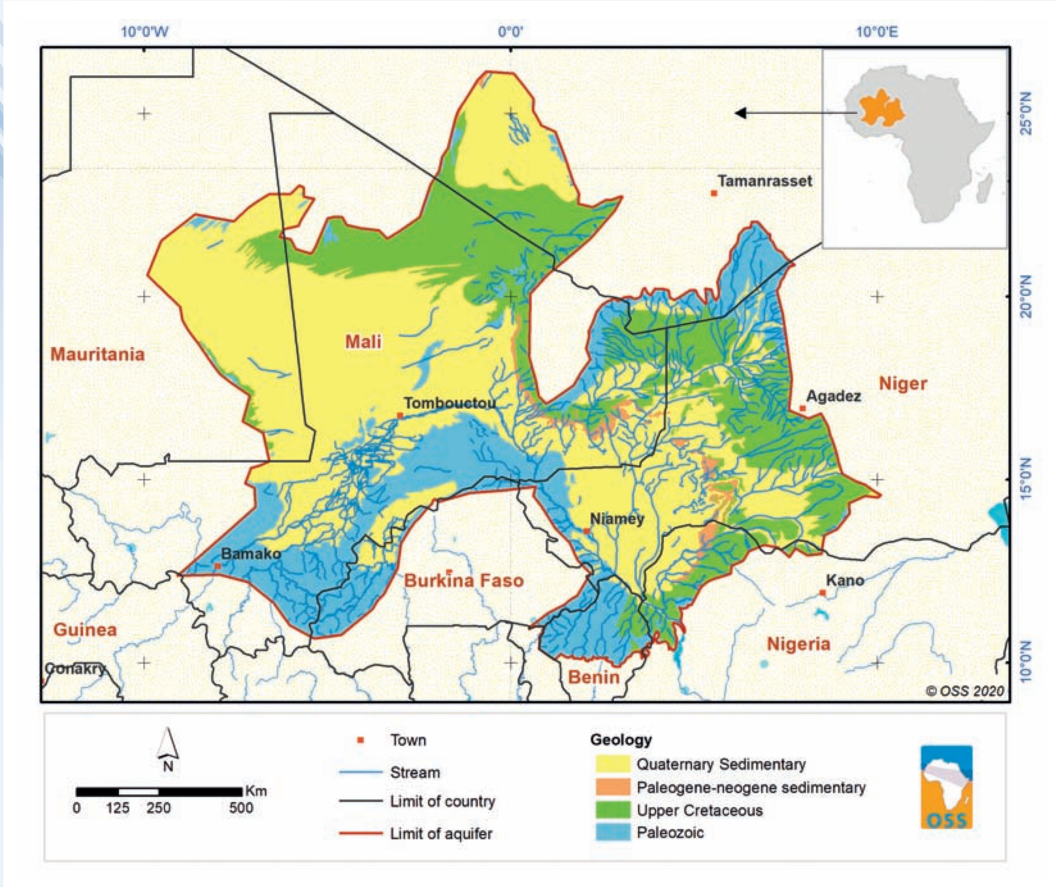

***Figure 18. Geographic and geological framework of the Iullemeden Taoudéni / Tanezrouft Aquifer System -** Data source: OSS, 2020, GIS-Africa, 2005*

The thicknesses of the aquifers vary between 50 m and 300 m on average and can reach 2000 m. Water reserves are estimated at 15,000 billion m^3 (10,000 billion m^3 for the TTAS and 5,000 billion m^3 for the IAS). The potential for renewable water resources is estimated at 19 billion m^3/year (11 billion m^3/year for the Taoudéni/Tanezrouft basin and 8 billion m^3/year for the Iullemeden).

Withdrawals for different uses are estimated at approximately 350 million m^3/year (65 million in Taoudéni/Tanezrouft and 285 million in Iullemeden), i.e. only 2% of the renewable water resources. Agricultural activities are mainly supported by surface water. Irrigated agriculture based on groundwater is increasingly practiced to increase food security in the region[7] (OSS, 2017).

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[7] Integrated and Consolidated Water Resources Management Project of the Iullemeden-Taoudéni / Tanezrouft Aquifer System and the Niger River

Groundwater is of good quality. However, in some areas, ITTAS undergoes degradation due in particular to hydro-agricultural activities (use of large amounts of agricultural inputs), industrial and mining activities (traditional gold mining), land and vegetation cover degradation in the aquifer recharge areas restricting the water supply thereto.

A memorandum of understanding was adopted in 2009 between Mali, Niger and Nigeria for the establishment of a framework for a consolidated management of the aquifer system.

Rainwater drainage and anti-erosion infrastructures, Nigeria

▪ Lake Chad Basin Aquifer System

The Lake Chad Basin Aquifer System (LCBAS) covers an approximately 1,900,000 km^2 area and extends mainly over Chad (53%), Niger (28%), the Central African Republic (9.2%), Nigeria (7.5%) and Cameroon (2.3%) **(Figure 19)**. It is a sedimentary aquifer system with three main levels, connected with depths that sometimes exceed 1000 m. The thicknesses of the aquifers vary between 300 and 700 m and the static levels are on average between 30 and 100 m to the ground *(UNESCO et al, 2006)*. Some parts (in the Continental Terminal) are flush and have an immediate contact with the surface water. Theoretical aquifer reserves are estimated at 5800 billion m^3 and annual recharge at 7 billion m^3 *(TWAP, 2016)*.

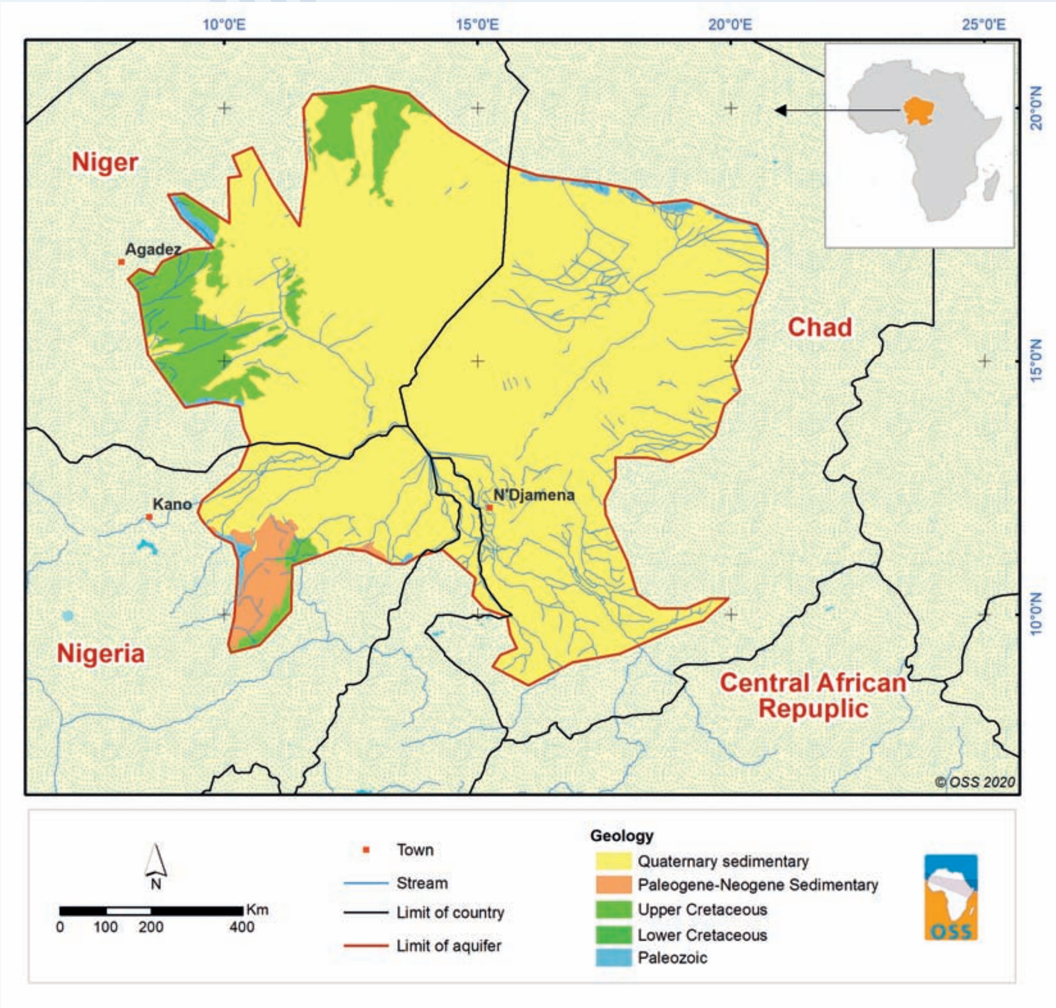

Figure 19. ***Geographic and geological framework of the Lake Chad Basin Aquifer System*** *- Data source: OSS, 2020, GIS-Africa, 2005*

In 2010, these withdrawals were evaluated at 0.28 billion m^3 in Chad and 0.15 billion m^3 in the Central African Republic, for a total of 0.43 billion m^3. The accurate values of current withdrawals from the entire aquifer are not known[8].

The current issues mainly relate to the contamination of the aquifer water. For example, in the northern region of Chad, around 30% of aquifer water is unfit for human consumption due to pollution. There is also a shortfall in the water table recharge and an increase in withdrawals resulting in significant drops in the piezometry in a number of places (up to 3 m in 30 years).

Reach/Millstream of the Chari river, Chad

▪ Mourzouk Aquifer System: Algeria, Libya, Niger, Chad

With a nearly 450,000 km^2 area, the Mourzouk basin **(Figure 20)** is one of the largest endorheic sedimentary basins in North Africa. Most of its area is located in Libya (435,000 km^2) with small extensions in Algeria, Niger and Chad.

[8] Assuming an average gross withdrawal of 50 l/day/inhab., the current withdrawals would amount to 0.73 billion m^3/year for the 40 million people living in the basin and one billion m^3/year if we include other needs (consumption of livestock, agriculture).

It is a two-layered aquifer system, mainly sandstone and its thicknesses can reach 2,500 m. The theoretical reserve volume is 4,800 billion m³. The renewal of the water table (0.15 billion m³/year) is low in view of the climate context of the region, because the annual rainfall levels do not exceed 50 mm.

Withdrawals, mainly carried out in Libya, were estimated at 2 billion m³/year in 2002 *(UNESCO et al., 2005; UNESCO-TWAP, 2016)*. There is no updated information on withdrawals. The continuous drop in piezometric levels is the biggest issue reported on this aquifer.

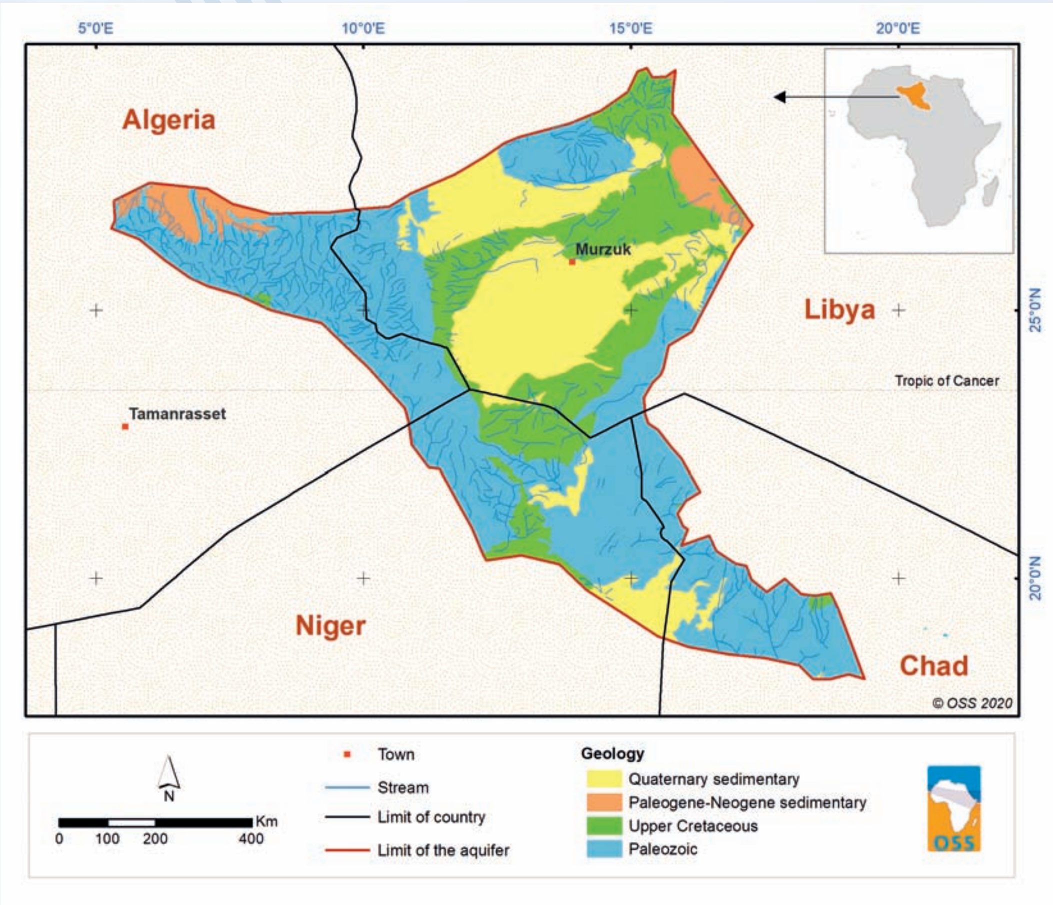

Figure 20. ***Geographic and geological framework of the Murzuk Aquifer System -*** *Data source: OSS, 2020, GIS-Africa, 2005*

▪ Senegal-Mauritania aquifer: Gambia, Guinea-Bissau, Mauritania, Senegal

The Senegal-Mauritania Aquifer System (SMAS), with an approximately 300,000 km² area, is shared between Senegal (159,000 km²), Mauritania (111,000 km²), Gambia (9,900 km²) and Guinea-Bissau (2,100 km²) **(Figure 21)**. Its coastline is 1,400 km long from north to south and takes the form of a coastal plain.

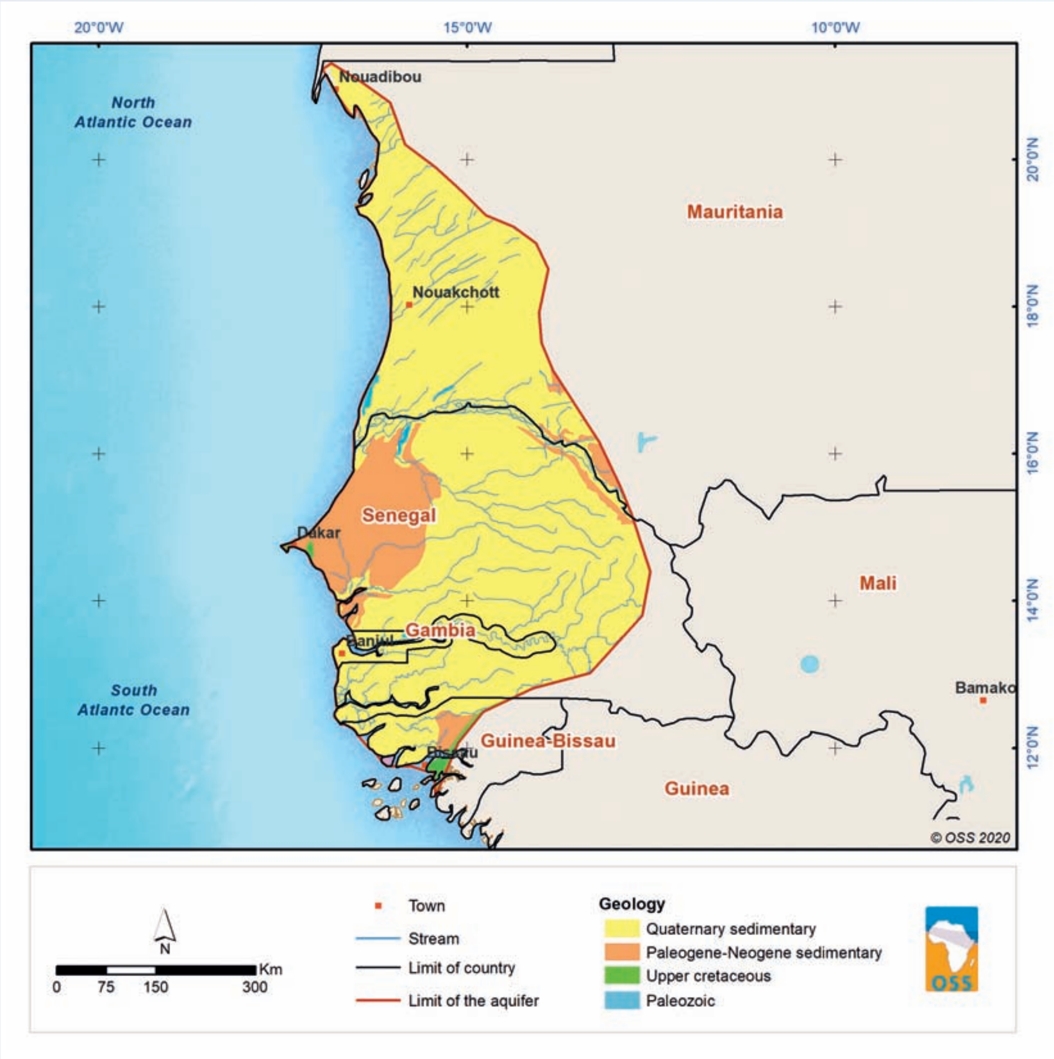

***Figure 21**. Geographic and geological framework of the Senegal-Mauritania Aquifer System - Data source: OSS, 2020; GIS-Africa, 2005*

The aquifer system is made up of three overlapping layers: the surface aquifer system, the intermediate aquifer system, and the deep aquifer system (Maastrichtian). Vertical and horizontal hydraulic connections exist between the different layers, making it difficult to individualize the main aquifers *(UNESCO and OSS, 2005)*. The thickness of the aquifer can reach 500 m at some layers. The theoretical reserve is approximately 1,500 billion m^3 and the annual recharge is estimated at 0.130 billion m^3 *(Margat, J. and Van der Gun, J., 2013)*.

The exploitation of the groundwater resource, outside the areas of influence of the rivers, began in the years 1970. Used primarily for the water supply of the populations and the livestock, this water is dedicated more and more to irrigation as part of the economic valuing of water points. Given the exceptionally good quality of some waters, a mineral water industry is booming in all the affected countries. The exploitation is still poorly controlled and the withdrawals generated are increasingly important because of the demographic growth and the development of the agro-pastoral and industrial sectors. In total, in 2002, the exploited flow was estimated at 200 million m^3/year, including 115 millions in Senegal, 55 millions in Gambia and Guinea-Bissau and 30 millions in Mauritania *(UNESCO et al., 2005)*. The volume of current withdrawals for the entire aquifer is not accurately established.

Excessive withdrawals lead to high drawdowns in the water table and the risk of marine intrusions in coastal areas. The water table is also subject to pollution from agricultural and industrial origins. There is an urgent need to initiate actions for consolidated governance of the aquifer, involving the 4 countries.

The Senegal-Mauritania Aquifer System has not benefited from a comprehensive hydrogeological study within its natural limits. Thus, there is a major challenge related to improving knowledge over it.

Stretch of water, Sudan

3. Ê MOBILIZATION AND USE OF WATER RESOURCES

Water intake threshold, North Senegal

3. MOBILIZATION AND USE OF WATER RESOURCES

3.1 Dam capacities

The current total capacity of the large dams in the OSS area of action, according to the available figures, is estimated at 479 billion m³ (Excl. the *Grand Ethiopian Renaissance Dam - GERD*, under construction in Ethiopia) (Aquastat, FAO, 2017). As for the number of dams and capacities/volumes mobilized, there is a great gap between the regions (Table 3 and Figure 22). Some 315 dams are identified in North Africa for a 198 billion m³ total capacity, 189 in West and Central Africa for a 123 billion m³ average capacity and 38 in East Africa for a 158 billion m³ capacity. Specifically for East Africa, this capacity will be increased to 232 billion m³ with the GERD start up. Thus, the total capacity of the large dams in the OSS area will reach 553 billion m³.

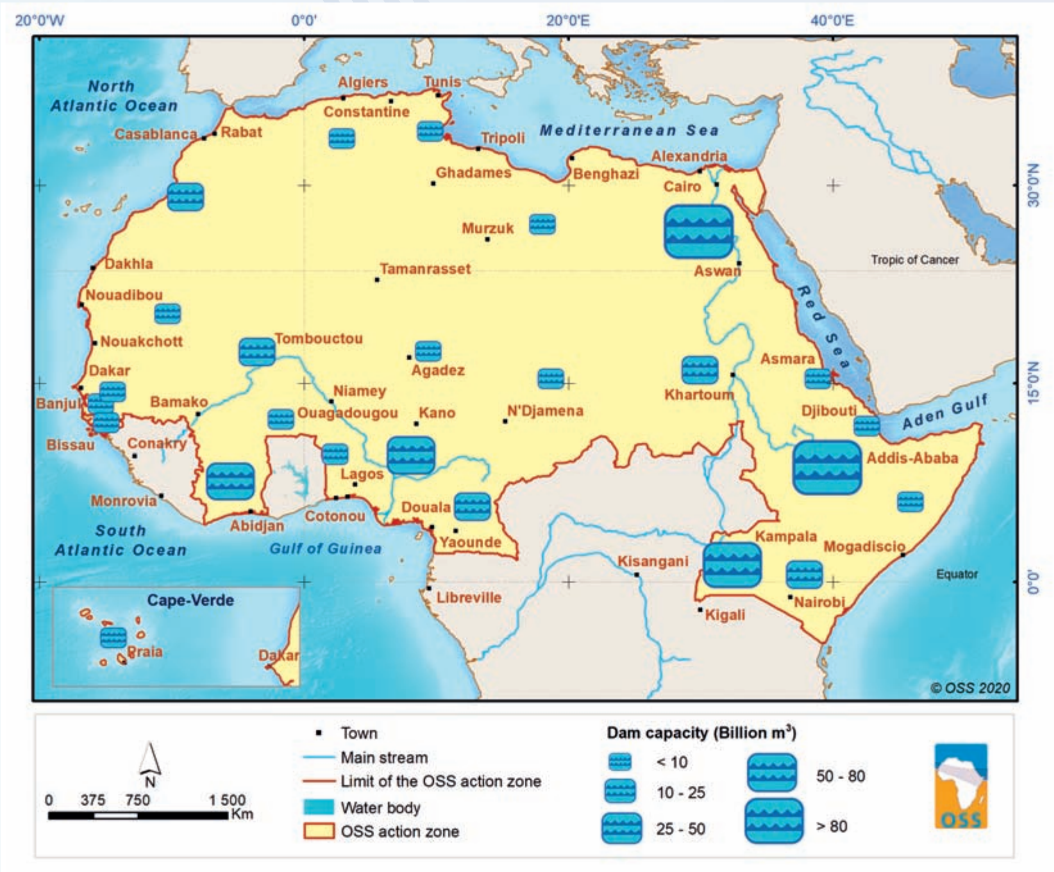

Figure 22. ***Dam capacities*** *- Data source: FAO-Aquastat, 2019*

Considering the total volumes mobilized by these dams, the shares by region are presented as follows: 41.95% in East Africa (including GERD), 35.80% in North Africa, and 22.25% in West and Central Africa.

Table 3. Number of large dams and capacity by region

Regions	Number of dams	Capacity (billion m^3)	Renewable surface water resources (billion m^3/year)	Capacity/Total capacity (%)
North Africa	315	198	92	35,80
West and Central Africa	189	123	943	22,25
East Africa**	38	232	268	41,95
Total	**542**	**553**	**1,303**	**100**

*** The figures include data from the GERD (74 billion m^3 capacity)*

In the OSS area of action, less than half of the available renewable surface water resources (1,302 billion m^3/year) are currently mobilized, which indicates that there are still enormous possibilities of exploitation. However, significant efforts are being made in the North African countries, which have set up an effective policy for the mobilization of surface water.

In North Africa, 198 billion m^3 are mobilized by dams, for about 91 billion m^3/year of available renewable surface water resources (Figure 23). Out of this mobilized volume, Egypt accounts for the largest share (almost 170 billion m^3), particularly through the *Aswan High Dam* (162 billion m^3) while only 60 billion m^3 of surface water crosses annually the country (only 0.5 billion m^3 of internal origin). Egypt then mobilizes more than three times the potential in surface water passing through its territory through twenty large dams erected mainly on the Nile.

The West and Central African countries and then East African countries have significant surface water resources but very low storage capacity. The capacities of the reservoirs represent 13% of the surface water volume for the West and Central African countries, and 59% for the East African countries. These countries should find support to develop policies for a greater mobilization of their surface water resources. Of course, climate constraints of the region must be taken into account when choosing the sites for erecting the dams in order to minimize losses of water stocks by evapotranspiration.

The Renaissance Dam in Ethiopia (Grand Ethiopian Renaissance Dam - GERD), under construction on the Blue Nile in the Benishangul-Gumuz region, is expected to be the largest hydroelectric dam in Africa (nearly three times the hydroelectric power of the Aswan High Dam). The structure, 1,780 m long and 175 m high, will have a 74 billion m^3 storage capacity (including 14.8 billion m^3 of permanent storage) for a water surface of 1,874 km^2 at a normal altitude of 640 m.

The electricity production capacity is estimated at around 6,450 MW (compared to 2,100 MW for Aswan). Ultimately, the structure will help substantially increase the mobilization capacity of the East African region, whose current capacity is 158 billion m^3 that will be increased to 232 billion m^3.

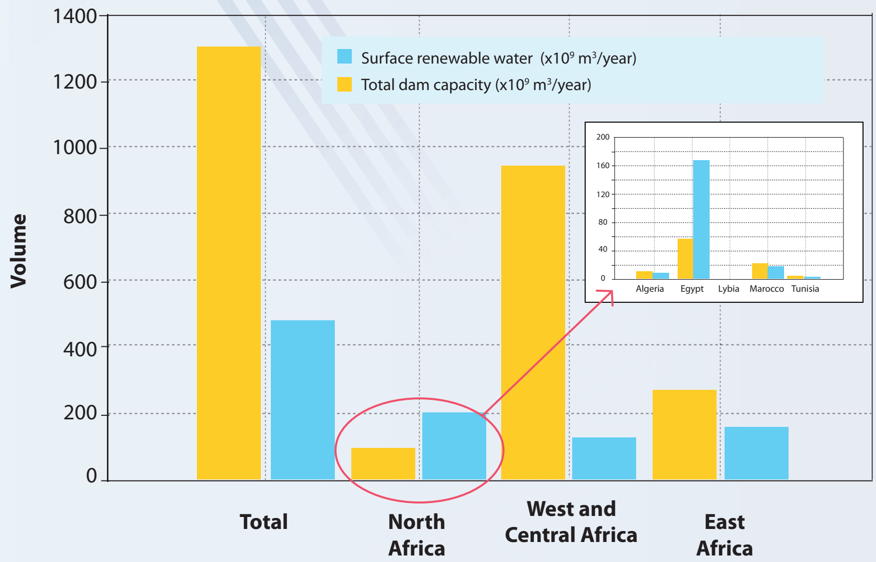

***Figure 23. Situation of surface water mobilization and comparison between the regions** - Data source: FAO-Aquastat, 2019*

3.2 Uses of water resources by type

3.2.1 Surface water

In the OSS area of action, the distribution by sector of the mobilized surface water is as follows *(WCD, 2000)*:

- Irrigation: 60% of the distributed volumes;
- Drinking water supply: 20%;
- Energy production (hydro-electricity): 6%;
- Flood control: 1%;
- Other uses (tourism, fishing, etc.): 13%.

Given its importance in terms of water withdrawals, the irrigation sector, the main consumer of the resource, will be particularly described below.

3.2.2.1 Irrigation potential in the OSS area

According to the FAO, the irrigation potential corresponds to the physical areas potentially irrigable. Different methods are used at a State and regional level to estimate this value.

Currently, this potential is estimated at 20 million hectares for the OSS area (Table 4), including 8 million hectares in North Africa, 6 million hectares in West and Central Africa and 6 million hectares in East Africa *(Aquastat, 2019)*.

Moulay Youssef dam, Morocco

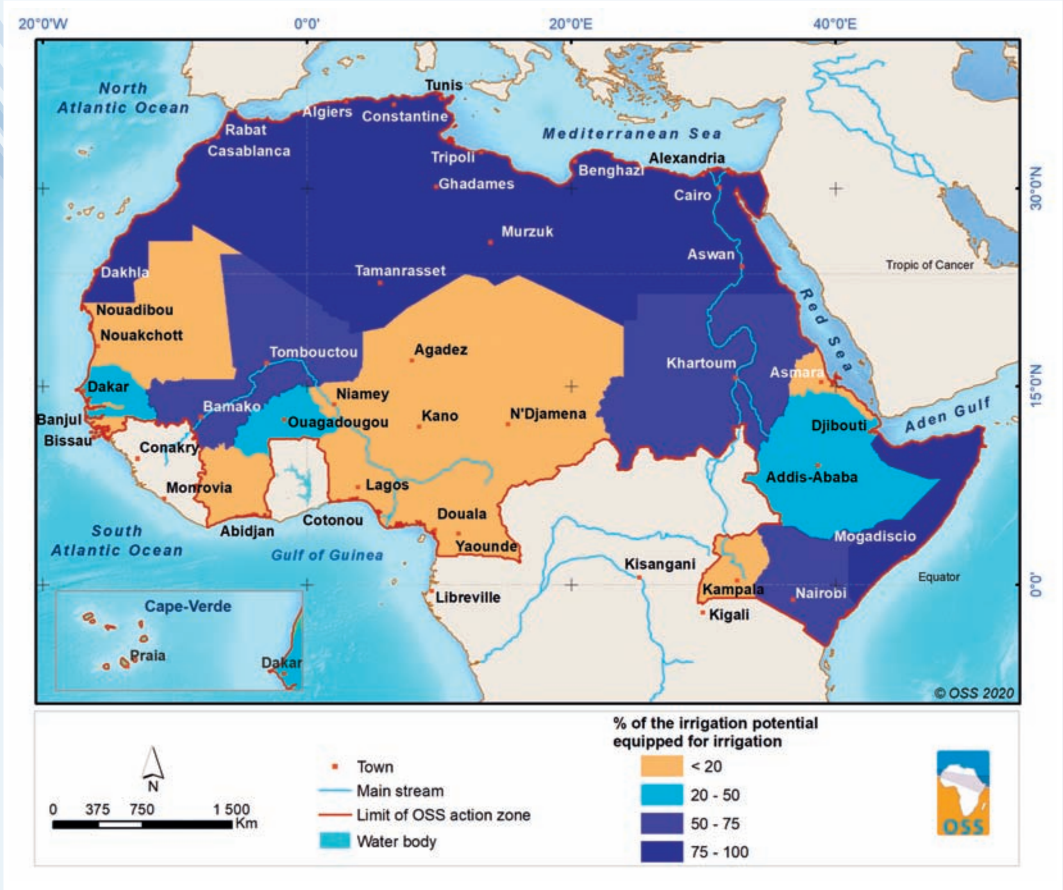

Figure 24. Exploited fraction (%) of the irrigation potential - *Data source: FAO-Aquastat, 2019*

The average exploited fraction of the irrigation potential in the OSS area of action increased from 35% in 1990 to 47% in 2017, a 12% increase (Figure 24).

At the sub-regional level, the used irrigation potential amounts to 91% in North Africa (excl. Libya)[1], 42% in East Africa and 29% in West and Central Africa.

West and Central Africa continue to practice rain-fed agriculture that is highly exposed to climate hazards. The few thousand developed areas are irrigated mainly from surface water, unlike North Africa where groundwater is the most used in this area.

[1] Libya's irrigable potential has increased from 40,000 ha to 400,000 ha following the implementation of the *"Great Man Made River"* program. Libya has thus exhausted all its natural potential.

Taking into consideration the exploited fraction of the irrigation potential, the countries in the OSS area of action can be classified into 3 categories:

- Countries with under-exploited irrigation potential (< 50%);
- Countries with moderately exploited irrigation potential (between 50% and 70%);
- Countries with highly exploited irrigation potential (> 70%).

Wind farm in the Rift Valley, Ethiopia

3.2.1.2 Irrigated areas and water withdrawals

Some 11.5 million hectares of land are currently irrigated in the OSS area of action, distributed as follows: 7.5 million hectares (65%) in North Africa, 3 million hectares (27%) in West and Central Africa and 1 million hectares (8%) in East Africa. As shown in **Table 4** and the map **(Figure 25)**, the largest developed areas are located in North Africa.

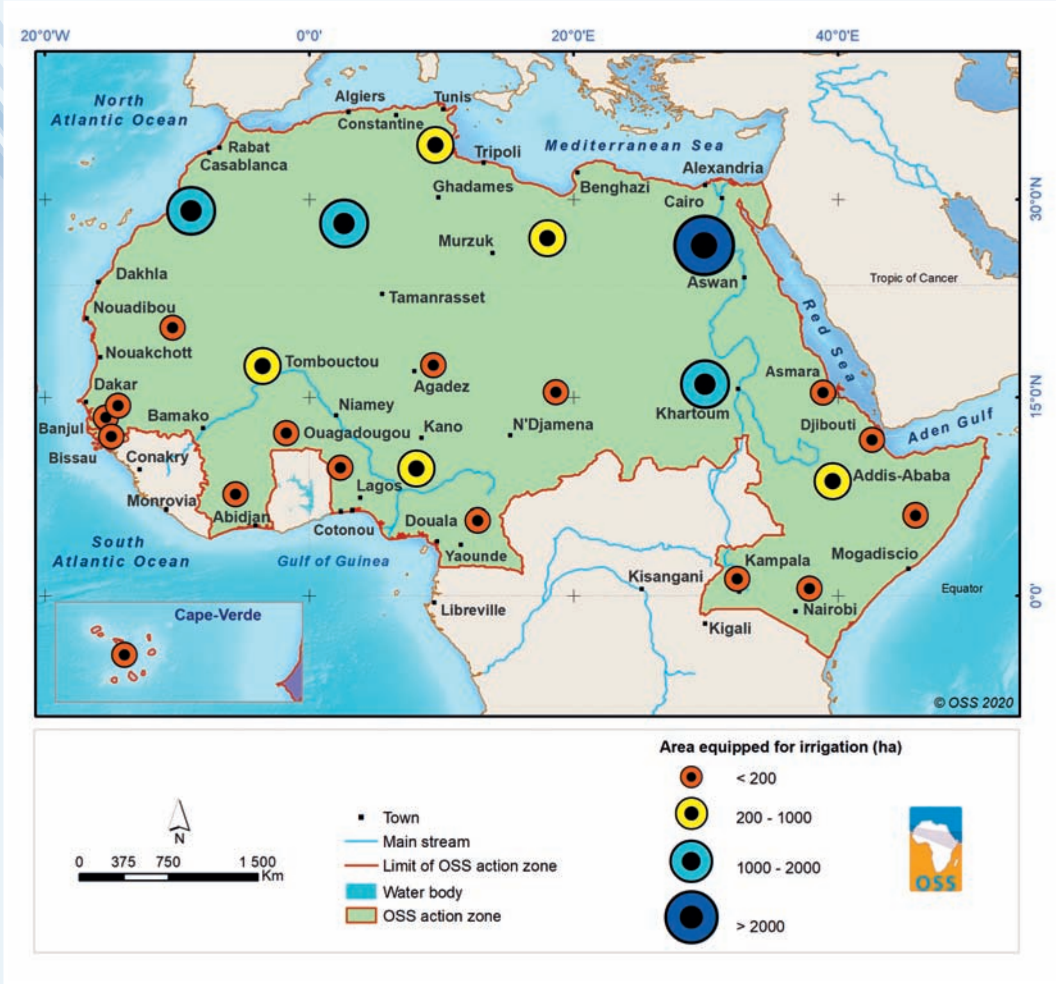

Figure 25. *Area equipped for irrigation by country - Data source: FAO-Aquastat, 2019*

Table 4. ***Irrigation potential and fractions developed by region***

	North Africa	West and Central Africa	East Africa	TOTAL (ha)
Irrigation potential (ha)	8, 000,000	6, 000,000	6, 000,000	20, 000,000
Irrigated areas (ha)	7, 500,000	3, 000,000	1, 000,000	11, 500,000
Average exploited fraction of the potential (%)	93.7	50	16.6	57.5**

*** Correspond to the mean percent of the average exploited fraction of the potential*

Every year, about 142 billion m^3 of water are withdrawn to irrigate the 11.5 million ha, i.e. about 12,000 m^3/ha. This value highly surpasses the average recorded worldwide (around 8,800 m^3/ha). It is likely that the irrigation techniques/methods (surface and gravity irrigation) that are currently predominant in the area and the climate conditions demonstrate this low effectiveness value.

Rainfed crops next to Douguia, Chad

3.2.2. Groundwater

- In North Africa, renewable groundwater is heavily exploited. (Table 5). The exploitation rate of renewable groundwater is nearly 80% on average; Morocco presents the lowest exploitation rate (nearly 58%).
- In West, Central and East Africa, withdrawals are still low (less than 10%), although the renewable water potential is significant and the needs for all kinds of uses are not met.

Detailed data on groundwater exploitation in each of the OSS member countries is given in Annex 3.

North African countries are unable to meet their water needs from renewable water and have recourse to other resources, in particular fossil water and non-conventional water.

The allocation of groundwater withdrawn for the different sectors (drinking water supply, irrigated agriculture, livestock farming, mining and energy industry) in the different regions of the OSS area of action is presented as follows:

- In North African countries, nearly 70% of groundwater withdrawals is used for agriculture, 20% for drinking water supply and 10% for other sectors (industry, tourism, etc.).

- In the other regions (West, Central and East Africa), the drinking water supply sector for urban and rural communities accounts for the largest share, nearly 90% of the withdrawn water.

However, the impacts of climate extreme events, along with the growing demand for water (demography, socio-economic development), have pushed West African countries to gradually develop all-seasons irrigated agriculture using modern water-saving techniques (drip, Californian system, etc.). Groundwater resources are currently subject to an ambitious land and water development program[2] that aims at significantly improving food security, especially in West Africa.

Table 5. ***Groundwater resources and exploitation by region***

Regions/Countries	Available renewable groundwater resources (109 m³/year)	Total renewable groundwater withdrawals (10^9 m³/year)	Exploitation rate of renewable groundwater resources (%)	Fossil groundwater withdrawals (10^9 m³/year)	Total groundwater withdrawals (10^9 m³/year)
	(A)	(B)	(B/A)	(C)	(B+C)
North Africa	16,83	13,26	78,97	10,31	23,57
West and Central Africa	288,56	6,91a	2,40	-	6,91
East Africa	59,32	5,08a	8,56	0,41b	5,49

Data source: FAO-Aquastat, 2017, National reports on the water sector situation, Report of the MEWINA study[3]

a With no recent data available, the estimate is made based on a specific consumption of 50 l/day/inhab., with all groundwater withdrawals in these regions being intended for human consumption.
b Sudan withdrawals from the Nubian Sandstones

3.2.3. Non-conventional water

Non-conventional water consists of desalinated seawater and treated wastewater. Their use contributes to meeting countries' water demand and can reduce the pressure on freshwater resources.

[2] «Sahel irrigation initiative Project» (SIIP), (Burkina Faso, Mali, Mauritania, Niger, Senegal and Chad)
[3] CEDARE (2012): Monitoring and evaluation for water in North Africa (MEWINA) – Libya 2012 state of the water report.

North African countries where conventional water is scarce have been using it for several decades. Significant efforts have therefore been made to build seawater desalination plants and wastewater treatment plants. Wastewater treatment and seawater desalination now also have a prominent place in the Maghreb national policies and strategies for developing resilience and adapting to climate change.

3.2.3.1 Seawater Desalination

Seawater desalination began to expand in North Africa from the 1980s, in order to improve drinking water supply services intended for certain urban areas.

Algeria began its first seawater desalination experiment after its independence in 1962 to supply coastal cities and towns with drinking water. The Algerian coast provides a dozen seawater desalination plants spread over several coastal towns. The current capacity of the country amounts to 770 million m^3/year (approximately 2.1 million m^3/day) and the country plans to reach 950 million m^3/year (approximately 2.6 million m^3/day) by 2030 *(Djelouah, 2018; OSS, 2018)*.

In Egypt, the country's desalination capacity was around 86 million m^3/year (235,600 m^3/d) in 2018, i.e. less than 0.1% of daily water consumption, estimated at approximately 250 million m^3/d. The Government has set the target of reaching 365 million m^3/year (1 million m^3/day) by 2037 for the production of drinking water by desalination. This would represent 0.5% of the drinking water consumption by this time.

Since the 1960s, Libya had planned in its successive strategic water resources promotion plans, to prioritize the use of desalinated seawater. Some thirty desalination plants have been erected along the coast with a total capacity estimated at approximately 157 million m^3/year (411,000 m^3/day). However, due to the shutdown of a number of the plants[4], current production does not exceed 70 million m^3/year (191,800 m^3/day), i.e. only 57.6% of the established capacity. The main reason for this poor performance is the implementation of the artificial river «the Great Man-Made River (GMMR)[5] project», in which there was more interest. In 2014, the Libyan General Water Authority drew up a plan

[4] Only 8 plants are currently operational

[5] The artificial river «the Great Man-Made River (GMMR)» project is considered the largest water transfer project in the world, over a distance of 1,600 km, for a flow of more than 5 million m^3/d

for the establishment of 15 new desalination stations by 2025 for a production capacity of 728.2 million m^3/year (approximately 1,995 000 m^3/day) in order to cope with the growing water scarcity *(Hmidan, 2017)*.

In Morocco, public investments in desalination have been initiated since 1976. Several desalination plants were then established and their current capacity is approximately 11 million m^3/year (30,000 m^3/day) (OSS, 2018), with the objective of reaching 400 million m^3/year (1.1 million m^3/day) by 2030. Today, the largest desalination plant in the world is being erected in Morocco, in the coastal city of Agadir. It should initially produce around 100 million m^3/year (275,000 m^3/day) before reaching its maximum capacity of 164 million m^3/year (450,000 m^3/day) after processing. The water produced will benefit to domestic use and irrigation of crops (about 15,000 ha).

In Tunisia, the first desalination plant established in 1983 was erected in the Kerkennah Islands. Currently, 16 desalination plants are established for a drinking water production capacity of nearly 50 million m^3/year (approximately 134,000 m^3/day) *(OSS, 2018)*. 25 plants are expected to be erected by 2023, with a total production capacity of 160.6 million m^3/year (440,000 m^3/day).

The success of these ambitious States' policies in terms of desalination and the use of seawater, however, depends on the cost of energy. The sector continues to consume large amounts of energy, which makes it expensive. The great potential of North African countries in renewable energy, particularly solar energy, could be mobilized for this purpose and boost the success of these policies *(HCP, 2008; Ghilès, 2008)*.

From an environmental standpoint, defenders of environmental law believe that discharges of brines and chemicals generated by the desalination process are harmful to terrestrial and aquatic ecosystems. Policies and strategies in this area must therefore seriously take into account the ecological aspects in order to minimize the possible negative impacts.

3.2.3.2 Wastewater treatment and valuing

In the different North African countries, significant investments have been made, both in the construction of new plants and in the rehabilitation of existing ones. Tunisia comes first in terms of experience in the field of wastewater reuse. According to national data on the sanitation situation in the different countries and presented in **Table 6** and **Figure 26**, the rate of wastewater treatment is nearly 95% in Tunisia, 72% in Algeria and 43% in Morocco.

A small portion of treated wastewater, on average 12%, is reused for different uses, mainly crop irrigation and meet certain municipal needs, cooling in industries, and water table renewing through artificial recharge. The latter approach is sometimes used to promote the coastal aquifers protection against the intrusion of salty water and the fight against water resources pollution (wadis, dams, water tables, etc.).

Anti-erosion, water and soil conservation structures, Nigeria

Table 6. ***Situation of wastewater collection and treatment in North Africa***

	Quantity of wastewater produced (x 10^6 m^3/ year	Quantity of wastewater collected (x 10^6 m^3/ year)	Quantity of wastewater treated (x 10^6 m^3/ year)	Number of wastewater treatment plants	Fraction of treated water used (%) [b]	Year of reference	Comments
Algeria	1, 300	1, 062	935	187	-	2020	
Egypt	7, 078	6, 494	4, 282	384	12	2017	
Libya	504	167	40	79	13	2012	Updated data not available
Morocco	700	542	301	113	12	2018	Forecast to reach 160 plants in 2023
Tunisia	287	277,2	274	122	14	2018	

Data source: FAO-Aquastat, 2019; ONAS, Tunisia[6]; ONEE, Morocco[7]; ONA, Algeria[8]; Summary report, CREM project, 2018
[b] Data from 2014 (Jeuland, Marc 2014)

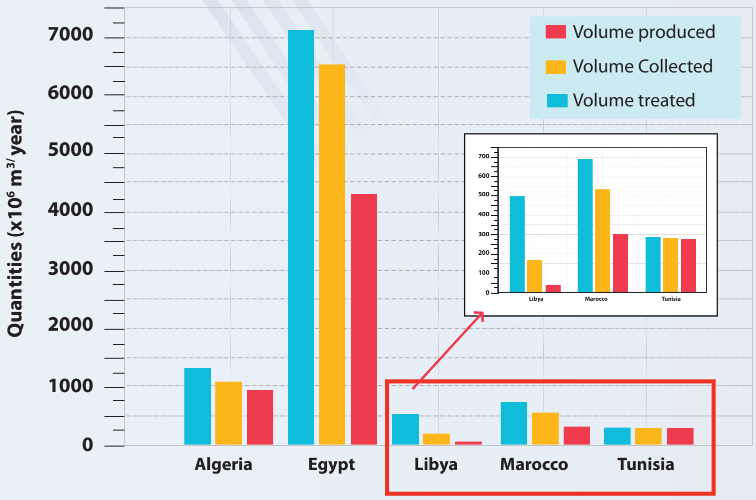

Figure 26. Situation of wastewater collection and treatment in North Africa - *Data source: FAO-Aquastat, 2019; ONAS, Tunisia; ONEE, Morocco, ONA, Algeria*

[6] http://www.onas.nat.tn/Fr/page.php?code=19,
[7] http://www.onep.ma/,
[8] https://ona-dz.org/L-ONA-en-chiffres.html,

3.3 Water withdrawals and distribution by sector of use and per inhabitant

3.3.1 Total water withdrawals

Between 1990 and 2015, total withdrawals (all sectors combined) increased from 130 billion m³ to about 180 billion m³ in the OSS area, a 50 billion m³ increase (about 40% increase). Egypt is beating the current withdrawals record in the OSS area with annual withdrawals of approximately 80 billion m³ **(Figure 27)**. In each of the other countries in the area, annual withdrawals hardly exceed 10 billion m³ with the exception of a few countries such as Sudan (26.93 billion m³), Nigeria (12.47 billion m³), Ethiopia (10.55 billion m³) and Morocco (10.43 billion m³). **Annex 4** presents detailed figures on withdrawals by sector of use in each of the OSS member countries.

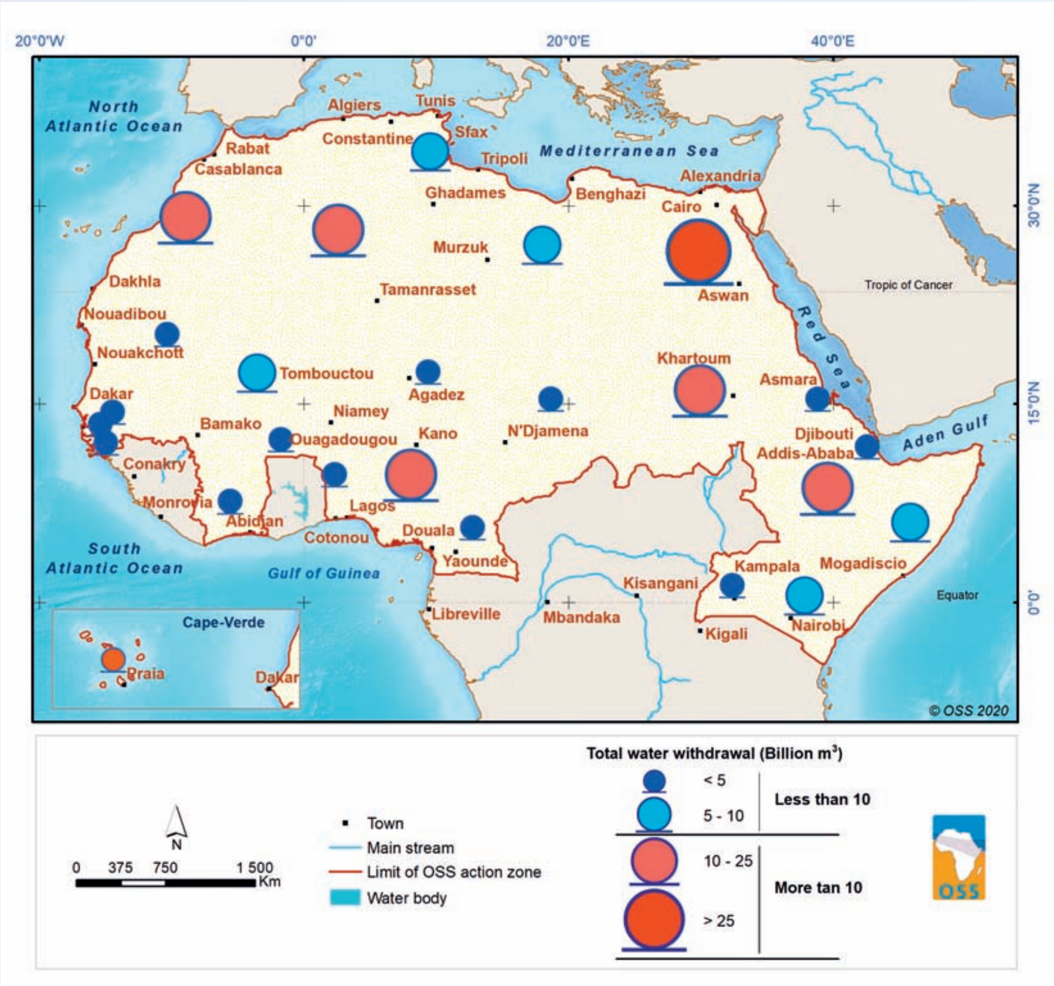

Figure 27. ***Total water withdrawals by country*** - *Data source: FAO-Aquastat, 2019*

3.3.2 Water withdrawals per inhabitant

Water withdrawals distributed over the population of the OSS area of action are on average 230 m³/inhab/year but highly changing according to the different regions and countries **(Figure 28)**:

- 542 m³/inhab/year for North Africa, (326 m³/inhab/year excl. Libya and Egypt; these two countries respectively take 940 m³/inhab/year and 795 m³/inhab/year) ;
- 163 m³/inhab/year for the East African countries;
- 87 m³/inhab/year for West and Central Africa.

By way of comparison, the world average of water withdrawals per inhabitant is 555 m³/inhab/year *(FAO, 2017)*.

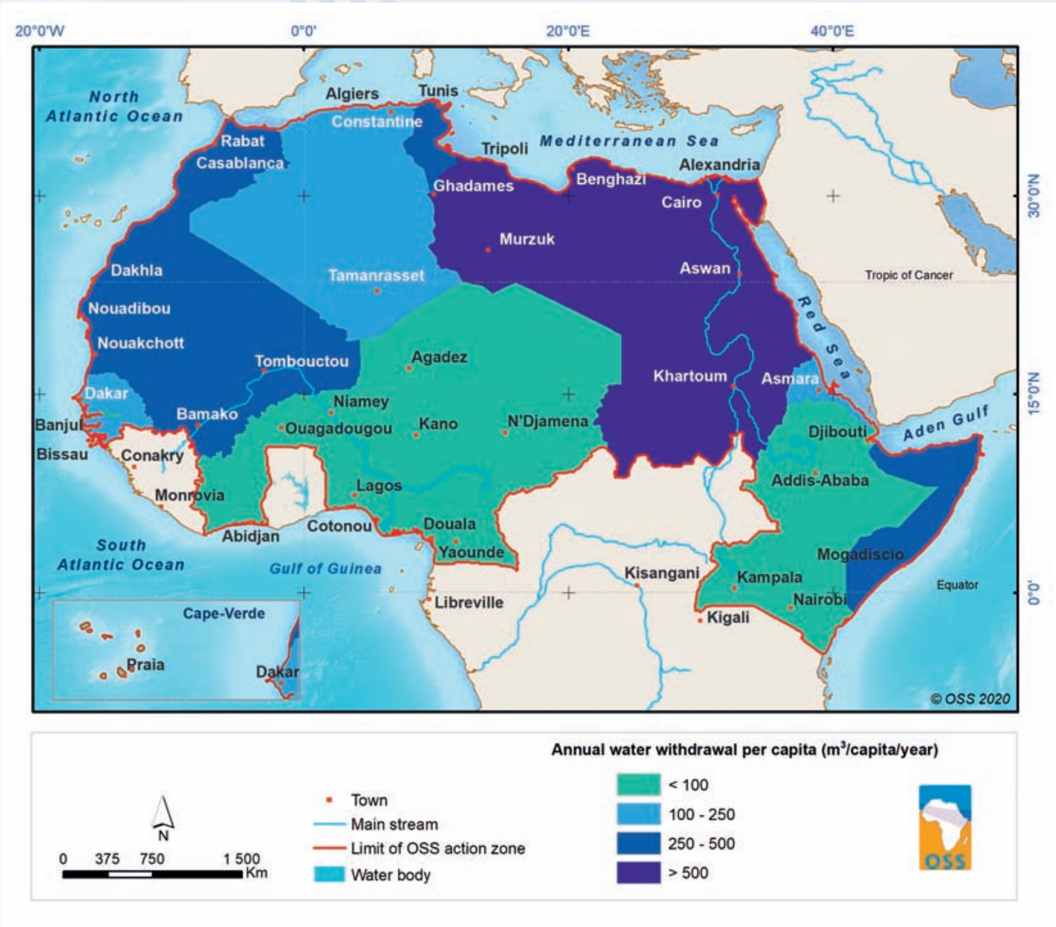

Figure 28. **Annual water withdrawals per inhabitant -** *Data source: FAO-Aquastat, 2019*

3.3.3 Water withdrawals according to the use sectors

Globally, agriculture consumption accounts for 70% on average of the water withdrawn compared to 20% for industrial uses and 10% for domestic uses. In the OSS area of action, the agricultural sector is still the largest consumer of water, with approximately 74% on average of total withdrawals (Figure 29). Domestic uses account for 20% and industry 7% of withdrawals.

The proportions of domestic withdrawals are increasing over time, going from 7% to 20% of total withdrawals between 1990 and 2019. The supply of drinking water has thus increased from 79 l/day/inhab. in 1990 to 97 l/day/inhab. (on average) in 2015. The North African countries (Algeria, Egypt, Libya, Morocco and Tunisia) are the countries with the highest drinking water supply in the OSS area (in 2019, drinking water supplies are around 120 l/day/inhab. for Algeria and 122 l/day/inhab. for Tunisia).

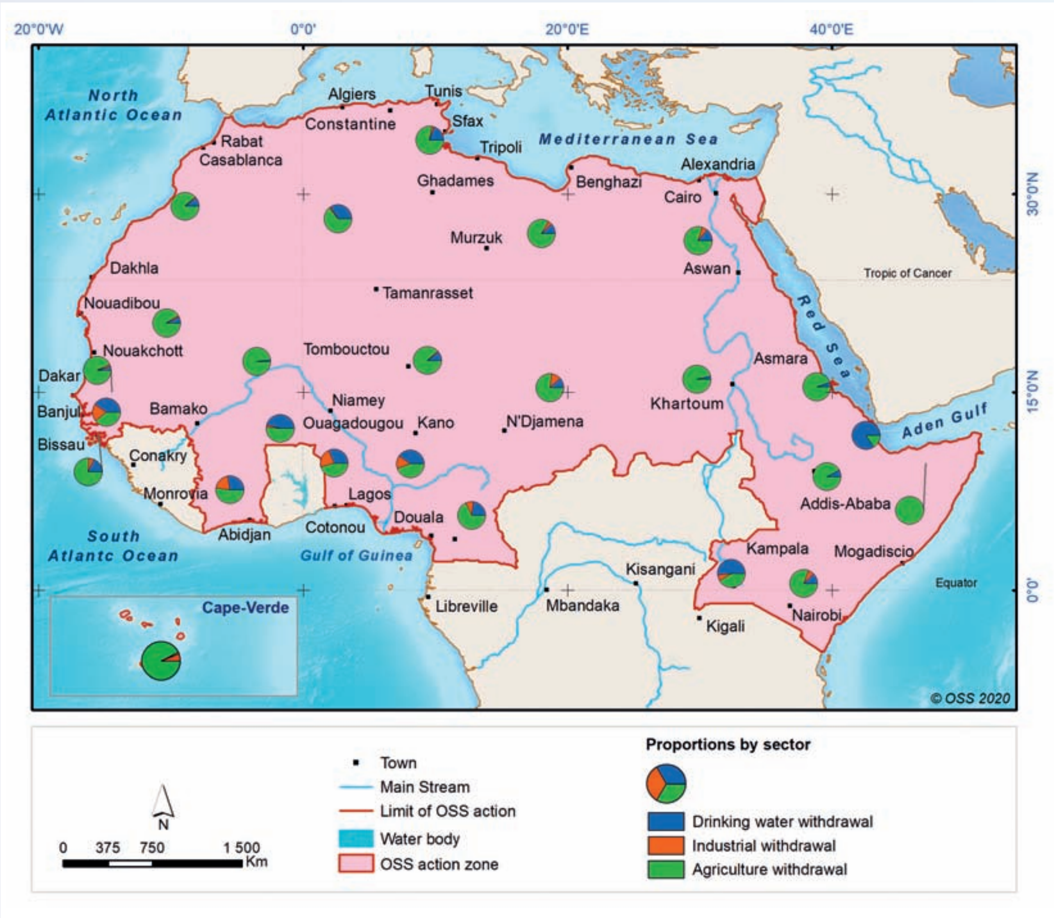

Figure 29. ***Proportion of annual water withdrawals by sector*** - *Data source: FAO-Aquastat, 2019*

3.4 Effectiveness and Efficiency of the water resources use

3.4.1 Effectiveness of the water resources use

The term «effectiveness» has diverse meanings and varies among sectors and areas of water use. Speaking of water resources management, this term is generally used to account for *(i)* water losses, which occur during the use or *(ii)* products generated per unit of water consumed. High effectiveness values indicate better performance of the established exploitation system. The overall effectiveness picture is as follows:

- In irrigated agriculture, and especially in gravity irrigation, the lowest effectiveness values are recorded (frequently 40% to 50%). Irrigated agriculture still results in significant water losses, requiring the modernization of irrigation infrastructure or the change of irrigation methods in order to optimize water savings.

- As for the drinking water distribution sector, the effectiveness of the networks is rarely higher than 70% and may drop to 50% in some countries. These figures highlight the significant losses and waste recorded and their impact on water withdrawals and the conservation of water reserves.

3.4.2 Efficiency of the water resources use

In addition to effectiveness, which is limited to the assessment of the systems' performance and the «physical» losses of water, efficiency (Water Use Efficiency) relates to the added value and the economic impact of the water use. This is a new indicator proposed within the framework of the Sustainable Development Goals (SDG - 6.4.1)[9], defined as «added value per volume of water withdrawn over time for a given economic activity (agriculture, industry and services), expressed in US dollars per cubic meter, in order to assess the efficiency of the water resources use"[10]. For a country, the water use efficiency at the national level corresponds to the total efficiency of the main economic sectors (agriculture, industry and services) weighted by the share of each sector in the total water withdrawals.

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[9] SDG 6.4.1: Water resources use efficiency. This indicator measures changes in the water resources use effectiveness and was designed to allow monitoring of the economic aspect of SDG target 6.4

[10] UN-Water 2017. Guide to monitoring SDG 6

Thus defined, the performance of this indicator depends closely on the effectiveness indicator.

In most cases, values fluctuate between 2 US$/m^3 (in countries whose economies depend on agriculture), and 1,000 US$/m^3 (in highly industrialized, service-based or natural resources dependent economies). In the OSS area, water use efficiency averages 6.5 US$/m^3, while the world average value amounts to 15.2 US$/m^3 (FAO, 2018). It is important to point out, however, that in most countries of the world and particularly in those in the OSS area of action, certain parameters that are crucial for calculating the indicator, such as the quantification of withdrawals are inadequately known.

Small-scale fishing, North Senegal

4. Ê QUANTITATIVE PRESSURE ON WATER RESOURCES

Tip of an irrigation pivot Oued Souf, Algeria

4. QUANTITATIVE PRESSURE ON WATER RESOURCES

4.1 Renewable water resources

The quantitative pressure on water resources in each country will be assessed through two parameters: on the one hand, *the availability of water per inhabitant and per year* and, on the other hand, *the level of withdrawals using the renewable water resources exploitation Index*[1].

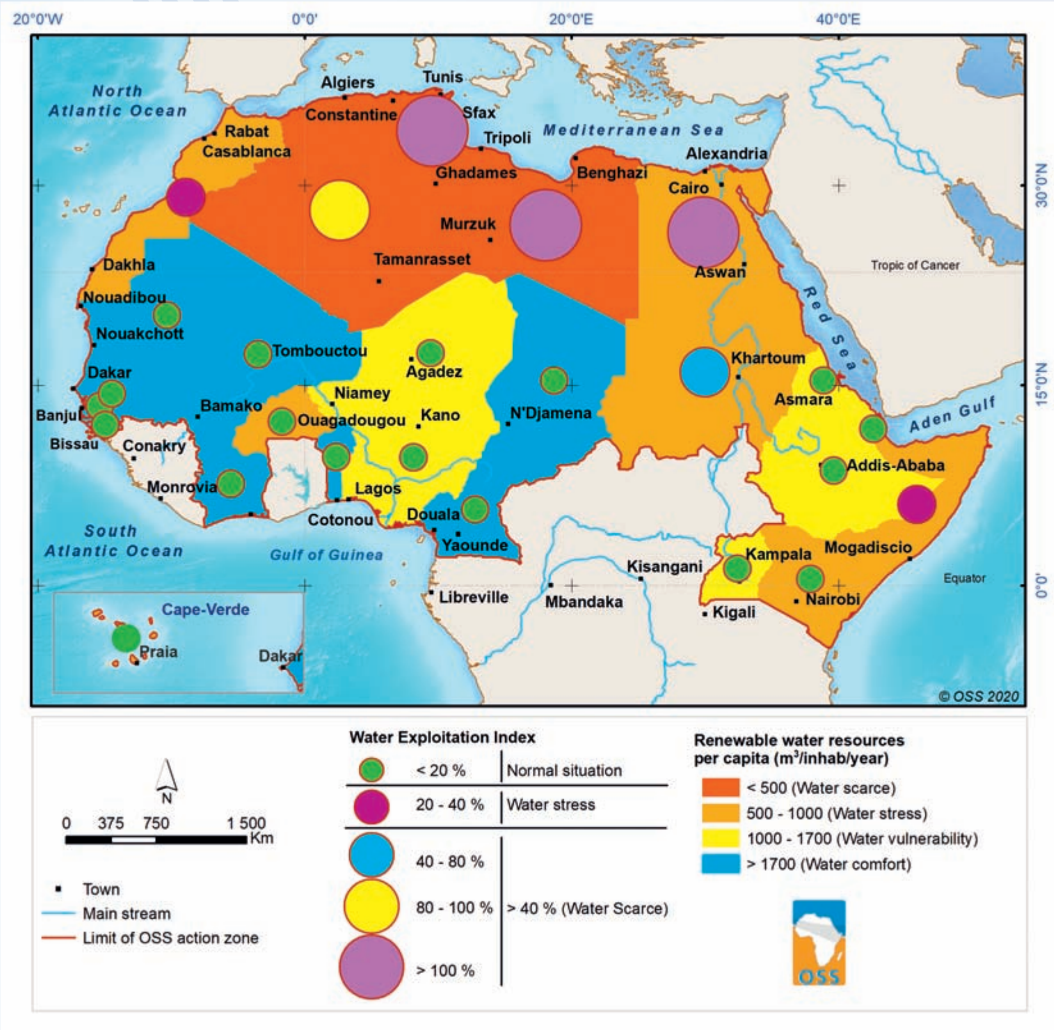

Figure 30. Renewable water resources and Water Exploitation Index - *Data source: FAO-Aquastat, 2019*

[1] In some references (e.g. UNESCO), this indicator is still called the "Water Stress Index". The higher this ratio, the greater the threat of water stress.

The water resources supplied to the populations constitute a basic indicator used to assess water abundance or scarcity in a given country. Different classes are defined according to the values of the indicator, namely water scarcity, water stress, vulnerability, security or water comfort.

As shown in the map in **Figure 30**, the situation of *water availability per inhabitant and per year* in the OSS countries can be summarized as follows:

- A first group of countries, experiencing a **water scarcity** situation, with water availability lower than 500 m^3/inhab/year. This group includes four countries: Algeria, Djibouti, Libya and Tunisia;
- A second group, experiencing a **water stress** situation, with internal water availability varying between 500 m^3/inhab/year and 1,000 m3/inhab/year. This group includes Burkina Faso, Cape Verde, Egypt, Kenya, Morocco, Somalia and Sudan;
- A third group, with water availability ranging between 1,000 m^3/inhab/year and 1,700 m^3/inhab/year, indicating a water vulnerability situation. These are Eritrea, Ethiopia, Niger, Nigeria and Uganda.
- A fourth group, with water availability exceeding 1,700 m^3/inhab/year indicating a **water security**, even **water comfort** situation, which includes Benin, Cameroon, Côte d'Ivoire, Gambia, Guinea, Mali, Mauritania, Senegal and Chad.

The Water Exploitation Index represents the ratio between the total volume of withdrawals and the total volume of renewable water resources in a country. According to **FAO (2002)** and **De Marsily, G. (2006)**, the level of *water stress* is reached for a country when the exploitation index is higher than 20% and a *water scarcity situation* sets in when the exploitation index is higher than 40%. According to this indicator, 5 countries (Algeria, Egypt, Libya, Sudan and Tunisia) live under water scarcity and two others (Morocco and Somalia) are experiencing water stress **(Figure 30)**.

The combined use of these two complementary indicators *(Water availability and Water Exploitation Index)* once again corroborates the alarming situation in the North African countries, which have all largely surpassed the scarcity threshold, with an exploitation index close to 100% and beyond. Egypt, Libya and Tunisia are experiencing the most critical situations.

The global analysis of the extent of the OSS area of action shows that the pressure of demands on water resources is highly changing between sub-regions and countries. As indicated above, said pressure is very high in North Africa and almost insignificant, and even minimal, in most of the countries of West, Central and East Africa (**Table 7**).

Forecasts of the population size in the OSS area of action show that its upward trend is likely to continue. This situation, combined with the climate change impacts on the depletion of water resources, will exacerbate the quantitative pressures on the already under-pressure resource, mainly in North Africa.

Table 7. ***Situation of total withdrawals and exploitation indices of renewable water resources***

Regions	Available renewable water resources (billion m^3/ year)	Withdrawals (billion m^3/year)					Exploitation index (%)
		Renewable Water			Fossil water		
		Surface water	Groundwater	Total renewable water withdrawals	Total fossil water withdrawals	Total withdrawals	
	A	B	C	D = B+C	E	F = D+E	G = F*100/A
North Africa	104,53[a]	85,00	13,26	98,26	10,31	108,57	103,86
East Africa	272,92	41,17	5,08	46,25	0,41	46,66	17,10
West and Central Africa	983,15	20,43	6,91	27,34	-	27,34	2,78

Data source: FAO-Aquastat, 2019

[a] *Egypt: 63.5 billion m^3 in total, including 1 billion m^3 internal (the country receives almost all of its water from outside); Morocco: 22 billion m^3; Algeria: 13.5 billion m^3; Tunisia: 4.9 billion m^3; Libya: 0.63 billion m^3.*

4.2 Fossil water resources

Some countries in the OSS area of action, particularly those in North Africa, are experiencing a water scarcity or stress situation and are already using almost all their renewable water resources (Figure 30 and Table 7 above). They have recourse to other types of resources, in particular fossil water, to meet the increasing water demands. The situation of fossil water exploitation by country is shown in Table 8.

Indeed, as indicated above (cf. § 2.3.2), the OSS area of action has significant fossil reserves *(Almost 590,000 billion m^3 in total) contained in large aquifers such as those of the Nubian Sandstone (500,000 billion m^3); NWSAS (60,000 billion m^3)*, etc.

However, these reserves can only be exploited by observing very strict measures/ precautions because they are hardly renewable, or even non-renewable and far from compensating for the volumes withdrawn. By way of illustration, the recharge of the NWSAS is 1 billion m^3/year and the Nubian Sandstone does not exceed 0.5 billion m^3/year.

Therefore, the exploitation patterns of these reserves must provide for efficient measures for their use and preservation. These measures relate to, inter alia, improving the effectiveness of exploitation networks, in order to limit wastewater losses, recycling and its reuse.

Bridge over Niger river, Niamey

Table 8. Level of exploitation of fossil reserves in the OSS area of action

Country	Year of reference	Withdrawals (billion m^3/year)				
		NWSAS	Nubian sandstone	Mourzouk	Djeffara	TOTAL by country
Algeria	2017	2,19	-	-	-	**2,19**
Egypt	2017	-	2,40	-	-	**2,40**
Libya	2017	0,30	1,50	2,00	1,19	**4,99**
Sudan	2012	-	0,41	-	-	**0,41**
Tunisia	2017	0,52	-	-	0,21	**0,73**
TOTAL by Aquifer		**3,01**	**4,31**	**2,00**	**1,40**	**10,72**

5.Ê QUALITATIVE PRESSURE ON WATER RESOURCES

Nigerian breeder drinking water from a fire hydrant/drinking fountain, Nigeria

5. QUALITATIVE PRESSURE ON WATER RESOURCES

Water resources are subject to pollution that lead to degrading their quality. This pollution can derive from industrial activities, domestic waste and agriculture. In the OSS area of action, these different sources of pollution do exist, but the most widespread and the most generalized are pollution of agricultural origin. As a result, an overview will be given on the situation of the use of chemical agricultural inputs (fertilizers and pesticides), which are potential sources of chemical water pollution.

Chemical agricultural fertilizers include nitrogen and phosphate fertilizers and potash. The arable land potential of the OSS area of action has been estimated at over 150 million hectares *(AQUASTAT, 2017)*. Across the entire OSS area, the average quantity of fertilizer used increased by 27% from 37 kg/ha to 47 kg/ha between 2000 and 2015. This average is subject to significant disparities for it ranges from 0.6 kg/ha in Niger to 646 kg/ha in Egypt (WB, 2015).

By way of comparison between regions, we register that North Africa alone uses a 157 kg/ha average (higher than the 138 kg/ha world average). The amounts of inputs used are 13 kg/ha on average in West and Central Africa and 11 kg/ha in East Africa.

As for pesticides, the amounts used are increasing, going from 18,000 tonnes in 1990 to 19,000 tonnes in 2015 (i.e. 6% increase in 25 years), i.e. an average consumption of 110 g/ha, with a significant disparity between the regions and countries. North Africa is the largest consumer of pesticides with 480 g/ha compared to West and Central Africa (37 g/ha) and East Africa (31 g/ha). According to the FAO, the amount of pesticides used globally was 2.12 kg/ha of arable land in 2015.

6. ACCESS TO BASIC SERVICES: SAFE DRINKING WATER AND SANITATION

Use of treated wastewater for the Golf Course in Marrakech, Morocco

6. ACCESS TO BASIC SERVICES: SAFE DRINKING WATER AND SANITATION

Access to drinking water and sanitation in the OSS area of action remains a major challenge for the years to come, despite the significant progress registered. There remains a fairly significant effort to be made to achieve the Sustainable Development Goals (SDG 6).

6.1 Access to safe drinking water

Access to safe drinking water is defined by the proportion of the population that is covered or has reasonable access to enough volume of drinking water. "Reasonable access" generally means access to 20 l/day/inhab. of safe drinking water available within a 15-minute walk, i.e. located within 1,000 m. Water is deemed drinkable when it does not contain concentrations of pathogens or chemical agents that may be harmful to health. Sources of drinking water can include boreholes, wells, as well as treated and uncontaminated surface water, the quality of which is regularly monitored and deemed acceptable by the structures responsible for public health *(WHO, UNICEF, 2019)*.

The average rate of access to drinking water in 2017 in the OSS area was approximately 74% **(Figure 31)**. However, there is a gap between regions and also between rural and urban localities. Urban areas have much better levels than rural areas. In 2017, the North African countries and Cape Verde (in West Africa) had an access level of over 92%, while the world average was around 91%. With the exception of a few countries, countries in the OSS area of action had a score of over 80% in urban areas in 2017, while, in rural areas, some localities had no drinking water supply structures, especially in sub-Saharan countries.

Given the demographic growth and economic and social changes, the demand for water will undoubtedly increase and the water scarcity issue can no longer be ruled out *(Plan Bleu, 2008)*.

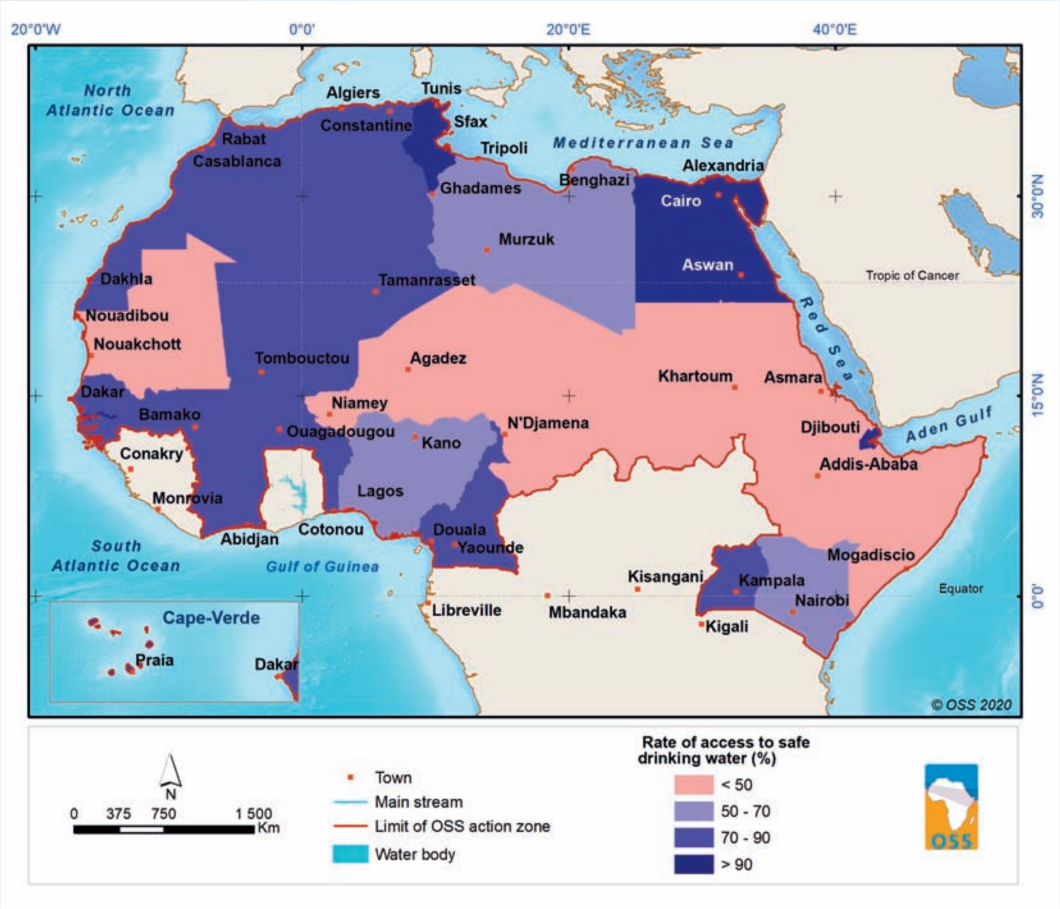

***Figure 31. Situation of access to drinking water in 2017** - Data source: WHO, UNICEF (2019). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene*

6.2 Access to sanitation

The access to sanitation rate represents the proportion of the population having a basic sanitation system (see definition in the glossary) for the disposal of human dung in the house or in the immediate vicinity (public sanitation network, septic tank)[1].

In 2017, in the OSS area of action, some 418 million people (i.e. 52% of its total population) did not have sustainable access to adequate sanitation. 70% of them live in rural areas (Figure 32).

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[1] Joint Monitoring Programme for Water Supply, Sanitation and Hygiene. Estimates on the use of water, sanitation and hygiene by country (2000-2017). Updated July 2017. (Data downloaded on 10/16/2019 via: https://washdata.org/data/household#!/table?geo0=region&geo1=sdg)

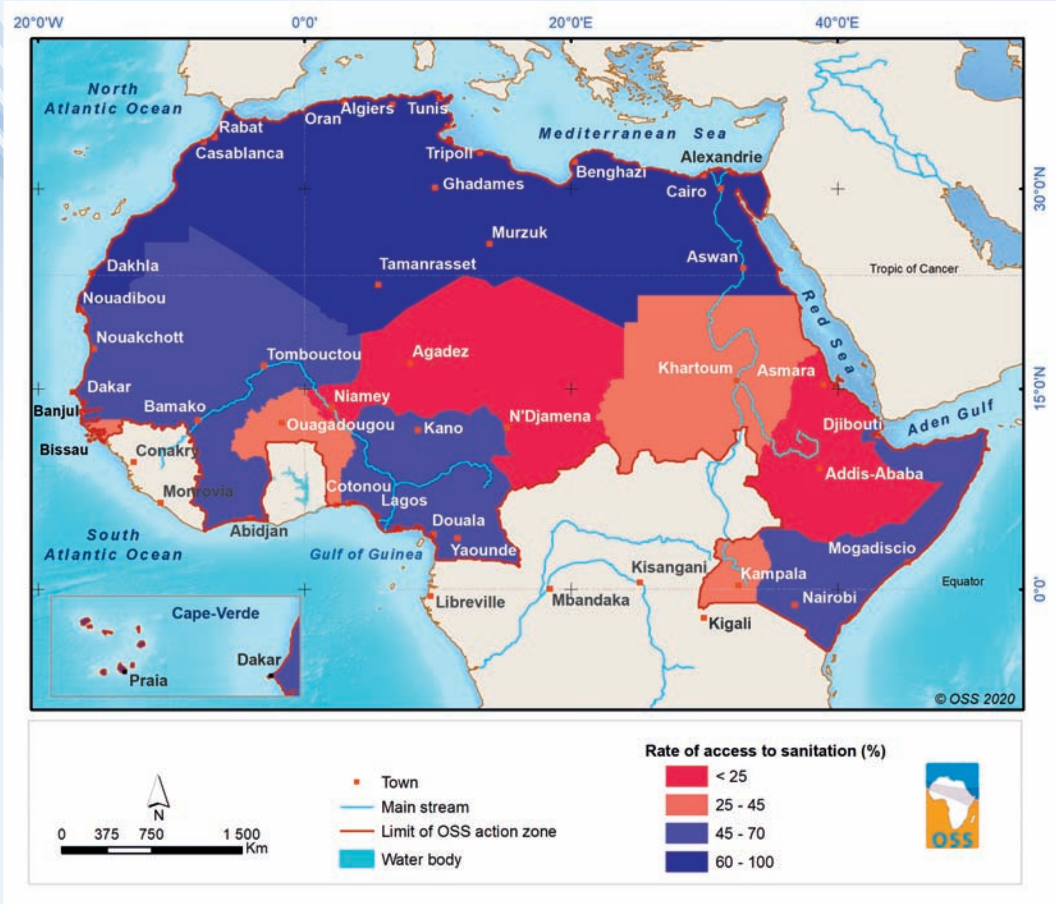

***Figure 32. Situation of access to sanitation in 2017** - Data source: WHO, UNICEF (2019). Joint Monitoring Programme for Water Supply, Sanitation and Hygiene*

North Africa and Cape Verde have registered the highest levels of access to sanitation with over 70% rates, a performance that surpasses the world average (around 47%). The gaps in access to sanitation between urban and rural areas are significant.

In some countries, the levels of access to sanitation registered in rural areas are still lower than 10%. With regard to the levels of access to basic services (water, hygiene and sanitation) in the OSS area, it is easy to see that there remains a fairly significant effort to be made to achieve SDG 6, in particular the universal access to water and end of open human dung disposal, despite the significant financial resources granted by the international community in the area (from 970 million USD to 2.3 billion USD between 2000 and 2015). However, there are large gaps within the area, with the North African countries having the best scores.

7. WATER GOVERNANCE AND MANAGEMENT

Tiered cultivation, Ethiopia

7. WATER GOVERNANCE AND MANAGEMENT

The United Nations recognize that good water governance will be the cornerstone for achieving Goal 6 of the SDGs[1]. This good governance is reflected in the preparation and implementation of appropriate policies and legal and institutional frameworks for water management. It is based on the principles of equitable access to resources and services, effectiveness, management by catchment, integrated approaches and balance between the development of socio-economic activities and the needs of natural habitats[2]. Given the different above-mentioned situations, it became vital to establish reinforced governance models for sustainable management.

We have to differentiate between governance at the national level and then governance at the transboundary basins and aquifers level. These management levels are not completely independent but interact with each other through different mechanisms established by the States.

7.1 Political and institutional environment

Most of the countries in the OSS area of action have a law that provides a comprehensive framework for the management of their water resources and defines the conditions for cooperation with other States with regard to shared water management. In countries that have no specific law for the management of water resources, some provisions are included in the laws relating to the environment or natural resources management.

With the emergence of the "Integrated Water Resources Management (IWRM)" approach after the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, several countries in the OSS area of action have prepared or updated their water policy and laws in order to comply with the IWRM principles.

The provisions and guidelines of these new instruments provide for the establishment of more appropriate governance frameworks for a more efficient and sustainable management of water resources with the participation of all-level relevant operators. This new approach promotes the distribution of

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[1] SDG 6: Guaranteeing access for all to water and sanitation and ensure sustainable management of water resources

[2] INBO (2014). Review of experiences of trans-boundary basin organizations in Africa - Best practices and recommendations. 105 p

roles and responsibilities between the State, local authorities and farmers, distributors, fishermen and fish farmers, industrial users, major regional planners, drinking water committees and protection associations at different management levels *(GWP, 2000)*. This requires taking into account, in the water management policy, the guidelines and aspirations of the policies of related sectors, such as agriculture, environment, land use planning, health, tourism, etc.

In West Africa, for example, this approach received political support at the regional level through the adoption by the Conference of Heads of State and Government of ECOWAS (i) of a Regional Action Plan of West Africa's IWRM (PARGIRE/AO) in Bamako in 2000 and (ii) of a new regional institutional framework for water resources management in Dakar in December 2001.

As in West Africa, most countries in other regions have adopted IWRM as an approach to water resources management. In East Africa, this process was introduced in several countries since 1995 and the East African Community (EAC) adopted a regional water policy and a comprehensive IWRM strategy. In Central Africa, the Economic Community of Central African States (ECCAS) established in 2009, a Regional Water Policy and a Regional IWRM Action Plan in 2014.

Following the adoption of these regional-level instruments, the IWRM process has gradually taken shape in the different States, still, a lot of work needs be done to achieve the identified objectives. An assessment of the progress made in 2018 with regard to the water resources governance at the global level, revealed that trans-sector coordination and public participation at the global level made the most significant progress, but that the financing, gender equality and management of aquifers are areas of concern *(UN, 2018)*.

In 2015, the United Nations integrated concerns relating to water governance in the 2030 Agenda for Sustainable Development, through targets 6.5[3] and 6.6[4] of SDG 6. This commits all member States (193) to strengthening the integrated management of water resources and associated ecosystems, as well as transboundary cooperation for shared water resources.

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[3] Target 6.5: Implementing integrated water resources management

[4] Target 6.6: Protecting and restoring aquatic ecosystems; Target 6.a: Developing international cooperation and capacity building

7.2 Governance of transboundary waters

The arrangements for the governance of transboundary water have affected surface water (rivers and lakes) more than groundwater, to such an extent that there are several networks of basin organizations by continent and on a global scale, and only six (06) bodies responsible for consultation in transboundary aquifers.

According to the International Network of Basin Organizations (INBO), the governance of transboundary water (river, lake and aquifer basins) is quite specific for different reasons:

- Water management responds to different political, legal and institutional frameworks, illustrating the sovereignty of riparian States over their water management domain;
- The interests and objectives of the water resources use are divergent depending on the upstream or downstream situation of the countries and depend on the integration degree of the management policies of everyone;
- The involvement of a country in transboundary cooperation is often correlated with the importance of its territory or its economy with regard to the transboundary resource;
- Conflicting situations over water sharing are more complex and more difficult to manage than national basins;
- The strategic water information and data dissemination is more delicate therein, particularly in a situation of water resources stress.

7.2.1 Case of river and lake basins

In the OSS area of action, the main large transboundary river basins (Gambia, Niger, Nile, Senegal, Volta, etc.) and lake basins (Chad) are fitted with consolidated management mechanisms through the Transboundary Basin Organizations (TBOs). These bodies' mission is the integrated development of water resources and related resources of these basins. The transboundary basins of the OSS area of action which currently have functional Basin Organizations are listed in Table 1 (see above).

These include, depending on the case:

- *At the institutional level:*
  - A Summit of Heads of State;
  - A Council/Committee of Ministers which acts as a decision-making body;
  - An Executing Body (Executive Secretariat/Executive Management/ High Commission);
  - An Experts Committee;
  - A Basin Committee/forum of stakeholders in the basin development (advisory body);
  - A Technical and Financial Partners' Committee.

Most TBOs also rely on «bridging structures» in countries as a coordination interface between them and the member States.

- *At the legal, regulatory and technical level:*
  - A Water Charter for the basin;
  - A Master Plan for the Development of the basin;
  - A Road Map for Water Development and Management.

Irrigation canal, Ethiopia

TBOs have proved to be efficient instruments providing riparian countries with many services such as (i) strengthening cooperation for riparian States, (ii) rational use of water resources and sharing of the various resulting benefits, and (iii) avoidance and management of conflicts between States sharing the basin.

Despite this significant progress, many challenges still need to be dealt with in order to increase the performance of these organizations.

7.2.2 Case of aquifers

Groundwater has long received little consideration in shared water treaties, unlike surface water. The brainwork on the management of transboundary aquifers has only recently developed under the impetus of international organizations.

Basically, out of the 608 transboundary aquifers in the world, 6 aquifer systems, including 2 in Africa (located in the OSS area of action), currently have a consultation framework:

- **The Nubian Sandstone Aquifer System (Egypt, Libya, Sudan and Chad):** An intergovernmental body called *«Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System»* has been operational since 1991 with its headquarters located in Tripoli (Libya) for a consolidated governance of the resources of this aquifer.

- **The North Western Sahara Aquifer System (Algeria, Libya and Tunisia):** In 2008, the three countries set up a permanent structure called *"NWSAS Consultation Mechanism"* to coordinate the NWSAS water resources management. The Mechanism's technical unit is housed in Tunis at the OSS headquarters.

It is worth noting that for the **Iullemeden-Taoudéni/Tanezrouft Aquifer System (ITTAS)**, the memorandum of understanding initially adopted in 2009 between Mali, Niger and Nigeria for the Iullemeden Aquifer System (IAS) must be replaced by a new protocol submitted in 2014 to the seven relevant countries of the Iullemeden-Taoudéni/Tanezrouft Aquifer System[5].

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[5] Algeria, Benin, Burkina Faso, Mali, Mauritania, Niger and Nigeria

The main legal instruments relating to international groundwater are:

- The "Draft articles on the law of transboundary aquifers", annexed to the United Nations Resolution 63/124 of December 11, 2008)[6];
- The "Model Provisions on transboundary groundwater" (2012) under the auspices of the 1992 Convention of the United Nations Economic Commission for Europe (UNECE) on the protection and use of transboundary watercourses and international lakes (UNECE, 2012).

Stretch of water for livestock watering, Ethiopia

[6] Resolution 63/124 - The law of trans-boundary aquifers (A/63/439). Sixty-third session, Item 75 of the agenda of the United Nations General Assembly (UNGA). Resolution adopted by the General Assembly on December 11, 2008

8. Conclusion

Wetland landscape, Togo

8. CONCLUSION

Despite the uncertainties about the available data, this monograph highlights the following points:

- An obvious inequality in the availability of renewable water resources according to the different regions of the OSS area of action:

    - The North African countries all lie in a water stress or water scarcity situation and this could deteriorate under demographic and climate constraints. However, basic services (access to drinking water and sanitation) are relatively well provided. In these countries, the only option would be both to strengthen strict water management, to resort to non-conventional resources and, if available, to fossil water, with all the necessary sustainability precautions.
    - In the West, Central and East African countries, water resources are widely available but access to water is still very poor. Mobilization efforts will have to be undertaken for without adequate access to water and sanitation, no economic development will be possible.

- A need to improve and strengthen the governance of transboundary water:

    - As for the transboundary river and lake basins of the OSS area, especially in West, Central and East Africa, most have, through basin organizations, consolidated management mechanisms that should benefit from greater supports.
    - On the other hand, with regard to shared aquifers, the establishment of consultation mechanisms is still modest; while those of the North Western Sahara (NWSAS) and the Nubian Sandstone Aquifer Systems are operational, the Iullemeden Taoudéni/Tanezrouft Aquifer System (ITTAS) one is lagging behind and no forecasts are made for the ten other main shared aquifers.

- Significant gaps in the availability of reliable and up-to-date data: (i) Inadequate studies, measurement networks, metering systems and systematic inventories, (ii) Scarcity of water information systems and open databases, (iii) Inadequate exchange and sharing.

In order to support its member States in developing and implementing appropriate solutions to the above mentioned issues, the OSS has set goals included in its successive strategies.

With this in mind, the OSS 2030 strategy plans to «contribute to meeting the water needs of the populations in the OSS member States and to the sustainable management of these resources by placing water on top of international political agendas». This will consist of:

- Improving/strengthening knowledge of groundwater and surface water resources in the region, and their interactions, particularly with regard to shared water;
- Contributing to the establishment of planning tools to meet the water needs of the populations in the short, medium and long terms;
- Encouraging and supporting integrated, consolidated and sustainable water resources management policies;
- Contributing to the improvement and sustainability of the governance of shared water resources.

This will be hard to achieve: the issues to address in the region are numerous and have different natures, the financial means are lacking to solve them simultaneously. However, water remains the key to development, whether it be to support economic development, ensure better food sufficiency, reduce health problems, or fight against climate change.

Here is the message to convey, in a clear and reasoned manner, so that water rises on the political agendas and is really considered as a priority. This objective can only be achieved if all political, financial and technical operators involved in this process manage to coordinate and combine their efforts.

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Shrub savannah, North Benin

Annexes

Agro-forestry system, Tamalé, North Ghana

Annex 1. Full list of transboundary river basins in the oss area of action

Basin	Main course length (km)	Average flow at the mouth (m^3/s)	Catchment area (km^2)	Riparian countries *((The figures in brackets refer to the areas of the basin (in km^2) in the country)*	Mouth	Basin organization
Nile	6,650	2,830	3, 112,369	Burundi (13,260), Egypt (326,751), Eritrea (121,890), Ethiopia (365,117), Kenya (46,229), Uganda (231,366), Democratic Republic of the Congo (22,143), Sudan (1,978,506), Rwanda (19,876), Tanzania (84,200)	Mediterranean Sea	Nile Basin Initiative (NBI), created in 1999. Headquarters in Entebbe (Uganda).
Niger	4 ,184	6,000	2, 113,200	Algeria (161,300), Benin (45,300), Burkina Faso (82,900), Cameroon (88,100), Côte d'Ivoire (22,900), Guinea (95,900), Mali (540,700), Niger (497,900), Nigeria (584,193), Chad (16,400)	Atlantic Ocean	Niger Basin Authority (NBA), created in 1963. Headquarters in Niamey (Niger).
Senegal	1,790	640	436,000	Guinea (30,800), Mauritania (219,100), Mali (150,800), Senegal (35,200)	Atlantic Ocean	Organization for the Development of the Senegal River (OMVS), created in 1972. Headquarters in Dakar.
Volta	1,350	1,100	412,800	Benin (15,000), Burkina Faso (173,500), Côte d'Ivoire (135,000), Ghana (166,000), Togo (25,800), Mali (18,800)	Atlantic Ocean	Volta Basin Authority (VBA), created in 2007. Headquarters in Ouagadougou (Burkina Faso).
Comoé	759	106	78,100	Burkina Faso (16,900), Côte d'Ivoire (58,300), Ghana (2,200), Mali (700)	Atlantic Ocean	
Gambia	1,130	149	69,900	Gambia (5,900), Guinea (13,200), Senegal (50,700)	Atlantic Ocean	Organization for the Development of the Gambia River (OMVG), created in 1967. Headquarters in Dakar
Sassandra	840	550	68,200	Côte d'Ivoire (59,800), Guinea (8,400)	Atlantic Ocean	
Ouémé	500	170	59,500	Benin (49,400), Nigeria (9700), Togo (400)	Atlantic Ocean	
Cross	480	570	52,800	Cameroon (12,500), Nigeria (40,300)	Atlantic Ocean	

Basin	Main course length (km)	Average flow at the mouth (m^3/s)	Catchment area (km^2)	**Riparian countries** *((The figures in brackets refer to the areas of the basin (in km^2) in the country)*	Mouth	Basin organization
Atui	-	-	32,600	Mauritania (20,500), Morocco (12,100)	Atlantic Ocean	
Cavally	700	150	30,600	Côte d'Ivoire (16,600, Guinea (1,300), Liberia (12,700)	Atlantic Ocean	
Rio Corubal			24,000	Guinea-Bissau (6,500), Guinea (17,500)	Atlantic Ocean	
Medjerda	460	29	23,700	Algeria (7,900), Tunisia (15,800)	Mediterranean Sea	
Mono	350	55	23,400	Benin (1,100), Togo (22,300)	Atlantic Ocean	Mono Basin Authority (MBA), created in 2014. Headquarters in Cotonou (Benin).
Moa	-	-	22,500	Guinea (8,800), Liberia (2,900), Sierra Leone (10,800)	Atlantic Ocean	
Saint-Paul	-	-	21,200	Guinea (9,400), Liberia (11,800)	Atlantic Ocean	
Little Scarcies	-	-	18,900	Guinea (5,900), Sierra Leone (13,000)	Atlantic Ocean	
Saint John	-	-	15,600	Guinea (2,600), Liberia (13,000)	Atlantic Ocean	
Tanoé	-	-	15,600	Côte d'Ivoire (1,800), Ghana (13,800)	Atlantic Ocean	
Cestos	-	-	15,000	Côte d'Ivoire (2,200), Guinea (9,400), Liberia (16,600)	Atlantic Ocean	
Rio Geba	-	-	12,800	Guinea (50), Guinea-Bissau (8,700), Senegal (4,100)	Atlantic Ocean	
Guir	433	-	12,580	Algeria, Morocco	Mediterranean Sea	
Great Scarcies	-	-	12,100	Guinea (9,000), Sierra Leone (3,000)	Atlantic Ocean	
Loffa	-	-	11,400	Guinea (1,300), Liberia (10,100)	Atlantic Ocean	

Basin	Main course length (km)	Average flow at the mouth (m^3/s)	Catchment area (km^2)	**Riparian countries** *((The figures in brackets refer to the areas of the basin (in km^2) in the country)*	Mouth	Basin organization
Bia	-	-	11,100	Côte d'Ivoire (4,600), Ghana (6,500)	Atlantic Ocean	
Mana-Morro	-	-	6,900	Liberia (5,700), Sierra Leone (1,200)	Atlantic Ocean	
Akpa Yafi	-	-	4,900	Cameroon (3,000), Nigeria (1,900)	Atlantic Ocean	
Lake Chad	NA	NA	Topographic basin: 2,381,635 km^2 theoretically but the active or conventional basin is only 967,000 km^2	Cameroon, Central African Republic, Libya, Niger, Nigeria, Chad	Endorheic lake	Lake Chad Basin Commission (LCBC), created in 1964. Headquarters in Ndjamena (Chad).

Data Source: Hissel, 2013

Annex 2. Full list of transboundary aquifers in the oss area of action

N°	Aquifer name	Affected countries	Area [Km²]	Réserves [Billion m³]	Resources [Billion m³]
1	Nubian Sandstone Aquifer System	Egypt, Libya, Sudan, Chad	2, 000,000	500,000	0,5
2	Taoudeni/Tanezrouft Aquifer **	Algeria, Burkina Faso, Mali, Mauritania, Niger	2, 000,000	10,000	11
3	Lake Chad Basin Aquifer	Algeria, Cameroon, Central African Republic, Libya, Niger, Nigeria, Chad	1, 900,000	5,800	7
4	North Western Sahara Aquifer System	Algeria, Libya, Tunisia	1, 000,000	60,000	1
5	Karoo-carbonate Aquifer	Central African Republic, Democratic Republic of Congo, South Sudan	941,100		
6	Iullemeden Aquifer **	Algeria, Benin, Burkina Faso, Mali, Niger, Nigeria	500,000	5,000	8
7	Murzuk Aquifer	Algeria, Libya, Niger	450,000	4,800	0,15
8	Al Sudd basin (Bahr al Jabal) Aquifer	Ethiopia, Kenya, South Sudan	370,648		
9	Senegalo-Mauritanian Aquifer System	Gambia, Guinea-Bissau, Mauritania, Senegal	300,000	1,500	0,13
10	Tindouf Aquifer System	Algeria, Morocco, Mauritania	221,019	800	0,103
11	Benoue Valley Aquifer	Cameroon, Nigeria	219,001		
12	Baggara Basin	CAR, South Sudan, Sudan	213,600		
13	Volta Basin	Benin, Burkina Faso, Ghana, Niger, Togo	130,000		
14	Afar Rift Valley/Afar Triangle Aquifer	Djibouti, Eritrea, Ethiopia	51,000		
15	Gedaref Aquifer	Eritrea, Ethiopia, Sudan	51,000		
16	Rift Aquifer	Democratic Republic of Congo, Uganda, South Sudan	44,632		
17	Djeffara Aquifer System	Libya, Tunisia	43,000	170	0,6
18	Keta/Benin/Coastal basin Aquifer	Benin, Ghana, Nigeria, Togo	36,904		
19	Mereb Aquifer	Eritrea, Ethiopia	34,000		
20	Dawa Aquifer	Ethiopia, Kenya, Somalia	31,000		

N°	Aquifer name	Affected countries	Area [Km^2]	Réserves [Billion m^3]	Resources [Billion m^3]
21	Dawa	Ethiopia, Kenya, Somalia	31,000		
22	Ogaden-Juba Aquifer	Ethiopia, Somalia	31,000		
23	Shabelle	Ethiopia, Somalia	30,985		
24	Ain Beni Mathar Aquifer	Algeria, Morocco	18,315		
25	Errachidia Aquifer System	Algeria, Morocco,	17,000	320	0,2
26	Tano basin	Côte d'Ivoire, Ghana	16,063		
27	Kilimanjaro Aquifer	Kenya, Tanzania	14,579		
28	Merti Aquifer	Kenya, Somalia	12,000		
29	Cestos - Danane Aquifer	Côte d'Ivoire, Guinea, Liberia	9,403		
30	Triffa	Morocco, Algeria	9,100		
31	Rio Del Rey	Nigeria, Cameroon	6,442		
32	Kagera Aquifer	Tanzania, Rwanda, Uganda	5,779		
33	Mount Elgon Aquifer	Kenya, Uganda	4,900		
34	Angad Aquifer	Morocco, Algeria	4,677		
35	Figuig Aquifer	Morocco, Algeria	1,546		
36	Disa Aquifer	Chad, Sudan	1,482		
37	Jbel El Hamra Aquifer	Morocco, Algeria	561		
38	Chott Tigri-Lahouita Aquifer	Morocco, Algeria	356		
39	Rift volcanic rock Aquifer	Kenya, Tanzania			
40	Shabelle Aquifer	Ethiopia, Somalia			

Data source: OSS and IGRAC 2015
*** The two aquifers are connected by the Gao ditch or «Gao Strait» and thus form a single System, Iullemeden Taoudeni / Tanezrouft Aquifer System (ITTAS).*

Annex 3. Withdrawals by type of resources

Region	Country	Availability of renewable water resources (Billion m³/year)			Withdrawals (Billion m³/year)					Exploitation index (%)
					Renewable Water			Fossil water	TOTAL withdrawals	
		Surface water resources Total	Groundwater resources Total	Renewable water resources Total	Surface water	Groundwater	Total Renewable water	Total Fossil water		
		a	b	c = a + b	d	e	f = d + e	g	h = f + g	i = 100*h/c
North Africa	Algeria	11	2,50	13,50	5,38	2,50	7,88	2,10	9,98	73,91
	Egypt	56	7,50	63,50	68,73	6,37	75,10	2,40	77,50	122,05
	Libya	0,03	0,60	0,63	0,03	0,60	0,63	4,99	5,62	892,06
	Morocco	18	4	22	8,11	2,32	10,43	0	10,43	47,41
	Tunisia	2,70	2,20	4,90	2,76	1,48	4,26	0,65	4,88	99,49
	SUMMARY FOR NORTH AFRICA			**104,53**	**85,00**	**13,26**	**98,26**	**10,14**	**108,40**	**103,86**
West and Central Africa	Benin	26,09	1,80	26,39	0,09	0,22	0,31		0,31	1,17
	Burkina Faso	9	9,50	13,50	0,44	0,38	0,82		0,82	6,06
	Cape Verde	0,18	0,12	0,30	0,01	0,01	0,02		0,02	7,33
	Cameroon	278,10	100	283,10	0,49	0,48	0,97		0,97	0,34
	Côte d'Ivoire	81,30	37,84	84,14	0,68	0,48	1,16		1,16	1,38
	Gambia	8	0,50	8	0,05	0,04	0,09		0,09	1,13
	Guinea-Bissau	27,40	14	31,40	0,14	0,04	0,18		0,18	0,56
	Mali	110	20	120	4,82	0,37	5,19		5,19	4,32
	Mauritania	11,10	0,30	11,40	1,27	0,08	1,35		1,35	11,84
	Niger	31,55	2,50	34,05	1,31	0,44	1,75		1,75	5,13
	Nigeria	279,20	87	286,20	8,71	3,76	12,47		12,47	4,36
	Senegal	36,97	3,50	38,97	1,911	0,31	2,22		2,22	5,70
	Chad	44,20	11,50	45,70	0,58	0,30	0,88		0,88	1,92
	SUMMARY FOR WEST and CENTRAL AFRICA			**983,15**	**20,49**	**6,91**	**27,40**	**0**	**27,40**	**2,78**

Region	Country	Availability of renewable water resources (Billion m³/year)			Withdrawals (Billion m³/year)					Exploitation index (%)
					Renewable Water			Fossil water		
		Surface water resources Total	Groundwater resources Total	Renewable water resources Total	Surface water	Groundwater	Total Renewable water	Total Fossil water	TOTAL withdrawals	
		a	b	c = a + b	d	e	f = d + e	g	h = f + g	i = 100*h/c
East Africa	Djibouti	0,30	0,015	0,30	0,00	0,02	0,019		0,019	6,33
	Eritrea	7,22	0,50	7,32	0,52	0,06	0,58		0,58	7,96
	Ethiopia	120	20	122	8,45	2,1	10,55		10,55	8,65
	Kenya	30,20	3,50	30,70	3,05	0,98	4,03		4,03	13,13
	Uganda	60,10	29	60,10	0,007	0,83	0,84		0,84	1,39
	Somalia	14,40	3,30	14,70	3,008	0,29	3,30		3,30	22,44
	Sudan	35,80	3	37,80	26,13	0,80	26,93		26,93	71,24
	SUMMARY FOR EAST AFRICA			**272,92**	**41,17**	**5,08**	**46,25**	**0**	**46,25**	**17,10**

Data source: Aquastat, FAO 2017, National reports on the water sector situation, Report of the MEWINA[1] study and internal calculation assumption (OSS)
Internal calculation assumption (OSS): With no recent data available, the estimate of groundwater withdrawals is made based on a specific consumption of 50 l/day/inhab., with all groundwater withdrawals in these regions being intended for human consumption.

[1] CEDARE (2012): Monitoring and evaluation for water in North Africa (MEWINA) – Libya 2012 state of the water report

ANNEX 4. WITHDRAWALS BY SECTORS

Country	Withdrawals for the agricultural sector (Billion m³/year)	Withdrawals for the industrial sector (Billion m³/year)	Withdrawals for the drinking water (Billion m³/year)	Total withdrawals (Billion m³/year)
Algeria	6,40	0,19	3,39	9,98
Benin	0,06	0,03	0,22	0,31
Burkina Faso	0,42	0,02	0,38	0,82
Cameroon	0,74	0,15	0,25	0,97
Cape Verde	0,03	0,004	0,0016	0,022
Côte d'Ivoire	0,60	0,24	0,32	1,16
Djibouti	0,003	0	0,02	0,02
Egypt	61,35	5,40	10,75	77,50
Eritrea	0,55	0,001	0,03	0,58
Ethiopia	9,67	0,05	0,81	10,55
Gambia	0,04	0,021	0,041	0,09
Guinea-Bissau	0,14	0,01	0,03	0,18
Kenya	3,23	0,30	0,50	4,03
Libya	4,36	0,57	0,69	5,62
Mali	5,08	0,004	0,11	5,19
Mauritania	1,22	0,03	0,01	1,35
Morocco	9,156	0,21	1,06	10,43
Niger	1,54	0,04	0,18	1,75
Nigeria	5,51	1,97	5	12,47
Uganda	0,26	0,05	0,33	0,64
Senegal	2,07	0,06	0,010	2,22
Somalia	3,28	0,002	0,015	3,30
Sudan	25,91	0,08	0,95	26,93
Chad	0,67	0,10	0,10	0,88
Tunisia	3,77	0,14	0,97	4,88

Data source: FAO, Aquastat, 2019; National reports on the water sector situation

LIST OF ABBREVIATIONS

AMU	Arab Maghreb Union
ANBO	African Network of Basin Organizations
ANRH	National Agency for Hydraulic Resources (Algeria)
AQUASTAT	FAO's global information system on water and agriculture
CARI	International Action and Achievement Centre
CENSAD	Community of Sahel-Saharan States
CICOS	International Commission of the Congo-Oubangui-Sangha Basin
CIDA	Canadian International Development Agency
CILSS	Permanent Inter-State Committee for Drought Control in the Sahel
CRTEAN	Regional Centre for Remote Sensing of North African States
DRC	Democratic Republic of Congo
ENDA	Environment development action in the third world
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GERD	Grand Ethiopian Renaissance Dam
GICRESAIT	Integrated Water Resources Management of the Iullemeden Taoudéni / Tanezrouft Aquifer System and the Niger River
GMMR	Great Man-Made River
IGAD	Intergovernmental Authority on Development
IGRAC	International Groundwater Resources Assessment Centre
IHP	International Hydrological Program
INBO	International Network of Basin Organizations
Inhab	Inhabitant
IPEMED	Institute for Economic Prospective of the Mediterranean World
ITTAS	Iullemeden Taoudéni/Tanezrouft Aquifer System

IWRM	Integrated Water Resources Management
LCBC	Lake Chad Basin Commission
LWM	Land and Water Management
MBA	Mono Basin Authority
NBA	Niger Basin Authority
NBI	Nile Basin Initiative
NSAS	Nubian Sandstone Aquifer System
NWSAS	North Western Sahara Aquifer System
OMVG	Organization for the Development of the Gambia River
OMVS	Organization for the Development of the Senegal River
ONA	National Sanitation Office (Algeria)
ONAS	National Sanitation Office (Tunisia)
ONEE	National Office of Electricity and Drinking Water - (Morocco)
OSS	Sahara and Sahel Observatory
PAAGGW	Pan-African Agency of the Great Green Wall
PARGIRE/WA	Regional Action Plan for Integrated Water Resources Management / West Africa
PPP	Purchasing Power Parity
PWC	Permanent Water Commission
ReSaD	Sahel Desertification Network
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SIIP	Sahel Irrigation Initiative Project (Burkina Faso, Mali, Mauritania, Niger, Senegal and Chad)
SMAS	Senegal-Mauritania Aquifer System
TBOs	Transboundary Basin Organizations
TWAP	Transboundary Waters Assessment Programme
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program

UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
UNICEF	United Nations Children's Fund
USA	United States of America
VBA	Volta Basin Authority
WB	World Bank
WCD	World Commission on Dams
WHO	World Health Organization

TERMINOLOGY

Access to sanitation: It is evaluated as the percentage of people using improved sanitation facilities (connection to sewerage or to a septic tank, basic flushing toilets, improved and self-ventilated pit latrines, and slab or covered pit latrines).

Access to drinking water: It is evaluated as the percentage of people using improved drinking water sources. An improved drinking water source is a source of water supply which, given its structure, adequately protects water from any external contamination, in particular from faecal matter. According to the World Health Organization (WHO), drinking water is the one safe for human consumption.

Transboundary aquifer: It is an aquifer or an aquifer system, parts of which are located in two or more States.

Transboundary catchment is a Catchment covering the territory of several States.

Climate change: A change in climate, which can be detected by long-lasting (decades or more) changes in the average and/or variability of its properties.

Water comfort: A country is in a water comfort situation when the renewable water availability situation is greater than 2,500 m^3/inhab/year.

Governance: According to UNDP, it is the exercise of economic, political and administrative power to manage the country's affairs at all levels. [...]. It makes sure that political, social and economic priorities are based on a broad consensus in society and that the voices of the poorest and most vulnerable are placed on top of the decision-making process on the resources distribution for development.

Dependency index: It is an indicator expressing the percentage of total renewable water resources from other countries. A country with a 100% dependency index derives all its renewable water resources from outside, on the contrary, a country with a 0% dependency index does not receive any water from outside.

Exploitation index of renewable water resources: This is the share (%) of the water withdrawn, for all the needs of a country, compared to the average annual volume of renewable water resources.

Improved sanitation facility: It is a sanitation facility that should hygienically prevent any contact between humans and human dung.

Water scarcity: Physically speaking, water scarcity is registered when there is not enough water to meet all needs, including environmental needs. According to the FAO, the water scarcity threshold for a country is reached if the availability of renewable water is lower than 500 m^3/inhab/year.

Irrigation potential (ha): Area of potentially irrigable land. **Irrigable land** is defined as land that can be irrigated economically. Its estimate takes into account several parameters such as the availability of land and water resources, economic aspects (distance and/or difference in elevation between the land likely to be irrigated and the water available) and ecological aspects.

Water withdrawal: Defines the quantity of water extracted from its source for a particular use. Withdrawals can be classified according to use sectors or use types. The amount of the withdrawals for all sectors/categories corresponds to the total water withdrawals.

Exploitable water resources: These are the resources likely to be developed, taking into account in particular the economic and environmental applicability.

Renewable water resources: Quantity/volume of water that can be renewed every year. It takes into account renewable surface water and groundwater and can be classified into internal renewable water resources and external renewable water resources (flows generated outside the country but entering the country); **as opposed to non-renewable water resources known as fossil resources which** are hardly renewed.

Water stress: According to the FAO, a country lies under water stress if the availability of renewable water ranges between 500 m^3/inhab/year and 1,000 m^3/inhab/year.

Water vulnerability: According to the FAO, water vulnerability is identified if the water availability of a country or region ranges between 1,000 m^3/inhab/year and 1,700 m^3/inhab/year.

Design and printing

SIMPACT

Water in our regions

This work comes after two previous editions of monographs on water resources published by the Sahara and Sahel Observatory in 1995 and 2001.

It is a summary of useful data and information for decision-makers and managers, but also to every single person interested in water issues.

It also provides avenues for reflection and guidance to the different and relevant operators, in order to improve the management and development of water resources, in the area of intervention of the Sahara and Sahel Observatory.

Finally, this work has the particularity of being available in a modifiable digital Wiki-type format at the following address:

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ISBN : 978-9938-933-29-1

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