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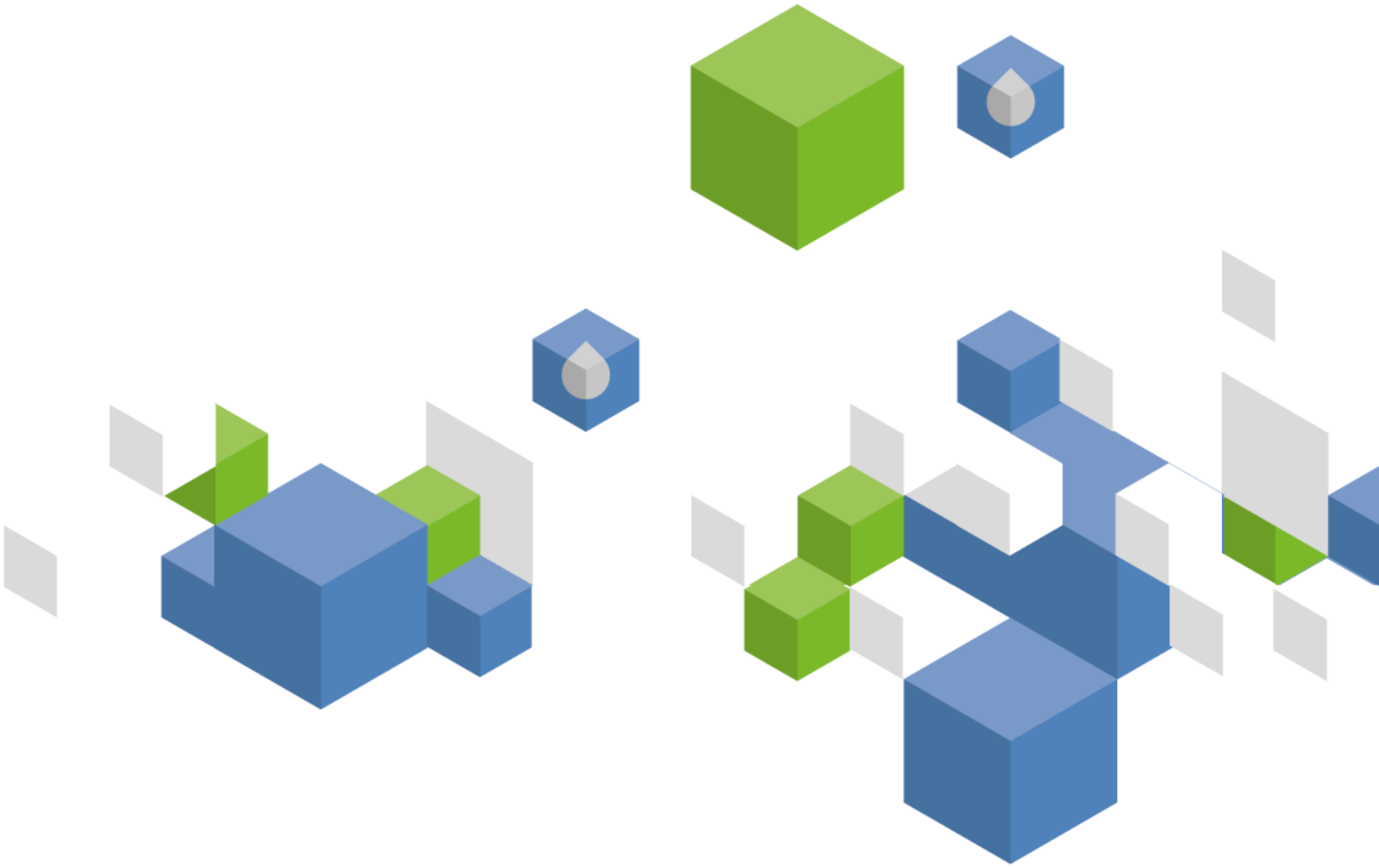

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Nigeria

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Nigeria is located in the tropical zone of West Africa and has a total area of 923 770 km^2. It is bordered to the west by Benin, to the northwest and north by Niger, to the northeast by Chad and to the east by Cameroon, while the Atlantic Ocean forms the southern limits of Nigerian territory. Land cover ranges from thick mangrove forests and dense rain forests in the south to a near-desert condition in the northeastern corner of the country. Nigeria is a federal republic constituted by 36 States and a capital territory.

Three broad ecological zones are commonly distinguished in the country: the northern Sudan Savannah, the Guinea Savannah zone or Middle Belt, and the southern rainforest zone. A mountainous zone is found at the border with Cameroon and the plateau zone in the centre of the country.

Total agricultural land is estimated at almost 71 million ha, which is 77 percent of the total area of the country. In 2013, the cultivated area was 40.5 million ha, of which arable land covered 34.0 million ha and permanent crops 6.5 million ha (Table 1). Internal water bodies cover around 1 million ha (FMWR, 2014).

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2013	92 377 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2013	70 800 000	ha
• As % of the total area of the country	2013	77	%
• Permanent meadows and pasture	2013	30 300 000	ha
• Cultivated area (arable land + area under permanent crops)	2013	40 500 000	ha
▪ As % of the total area of the country	2013	44	%
▪ Arable land (temp. crops + temp. fallow + temp. meadows)	2013	34 000 000	ha
▪ Area under permanent crops	2013	6 500 000	ha
Population:			
Total population	2015	182 202 000	inhabitants
▪ Of which rural	2015	52	%
Population density	2015	197	inhabitants/km^2
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2014	569 000	million US$/year
• Value added in agriculture (% of GDP)	2014	20	%
• GDP per capita	2014	3 123	US$/year
Human Development Index (highest = 1)	2014	0.514	-
Gender Inequality Index (equality = 0, inequality = 1)		-	-
Access to improved drinking water sources:			
Total population	2015	68.5	%
Urban population	2015	80.8	%
Rural population	2015	57.3	%

FIGURE 1
Map of Nigeria

NIGERIA **FAO - AQUASTAT, 2016**

Climate

The climate is semi-arid in the north and gradually changes toward the south into savanna and finally tropical rainforest with humid conditions. Except for an ultra-humid strip along the coast with rainfall averages of over 2 000 mm/year, where it rains almost all year round, rainfall patterns are marked by distinct wet and dry seasons of varying duration. The rainy season lasts from 9-12 months in the south to 2-3 months in the northern area. Rainfall is concentrated in the period June-September. Deficiency in total annual precipitation is a problem in parts of the country, particularly in the northern parts where it is only 400 mm. In most other areas, however, the major problems are the distribution in time and space and the low dependability of rainfall. Mean annual rainfall over the whole country is estimated at 1 150 mm. Mean annual pan evaporation is 2 450 mm in the southeast, 2 620 mm in the centre and 5 220 mm in the north of the country. The average air temperature is 26.6°C.

Population

Nigeria is by far the most populous country in Africa. With its 182 million people it accounts for over one-seventh of the total population of Africa's 54 countries (2015). The population density of 197 inhabitants/km^2 is also high, being almost five times the population density for Africa as a whole. Annual growth rate during 2005-2015 is about 2.7 percent and 52 percent of the population is rural in 2015, which is the same as 10 years earlier.

In 2014, the Human Development Index ranks Nigeria 152 among 188 countries. Life expectancy is 53 years and the under-five mortality is 113 per 1000 births, both progressing from 46 years and over 200 per 1000 in the 1990s. Around 66 percent of the children in 2010 are enrolled in primary education with over 10 point difference between girls (60 percent) and boys (71 percent). There is no data available regarding secondary school's enrolment, but only 10 percent are enrolled in tertiary education with a reduced gap between female (9 percent) and male (12 percent) (WB, 2016). Adult literacy is 51 percent in 2008, with a significant gap between female literacy (41 percent) and male literacy (61 percent). Poverty concerns almost half of the population (46 percent) in 2009 and is more common in rural areas (53 percent of the rural population). Despite steady GDP growth, poverty increased over the period 2004-2010 as a result of growing unemployment, especially in the northern areas (FMWR, 2014). In 2015, 81 percent of the urban and 57 percent of the rural population were using improved drinking water sources, that is 69 percent of the total population This represents a major improvement since 2002 when only 60 percent of the population had access to an improved drinking water source (JMP, 2015).

ECONOMY, AGRICULTURE AND FOOD SECURITY

The economy is highly dependent on oil revenues, which account for about 90 percent of total exports and for nearly 75 percent of government revenues (WB, 2014). The country's gross domestic product (GDP) was estimated at US$569 000 million in 2014 and the contribution from agriculture was 20 percent. Agriculture provides occupation to 31 percent of the economically active population in 2007 (FMWR, 2014) and is thus the largest employer in the country, especially considering the fact that 45 percent of the economically active population unemployed (WB, 2014).

Nigerian agriculture, however, remained until recently largely uncompetitive in major crops when compared with international markets (WB, 2014) and required large food imports. But between 2011 and 2014 drastic reforms of the agricultural sector, aimed at increasing production and attracting investments through incentives for agricultural commodity producers, led to creation of jobs, sharp increase in food production and thus reduction in food imports.

Farming systems are mainly smallholder-based and agricultural landholdings are scattered. Simple, low-input technology is employed, resulting in low-output labour productivity. A typical farm holds an average of 2.5 plots of 0.5 ha each (NBS, FMARD and WB, 2014). Nigeria's wide range of agro-ecological zones allows for a diversity of crop production activities:

- The dry northern savannah is suitable for sorghum, millet, maize, groundnuts and cotton, with sorghum and millet being the most important crops
- In the middle belt and the south the main food crops are cassava, yam, plantain, maize and sorghum
- In the south the main cash crops are oil palm, cocoa and rubber
- Low-lying and seasonally flooded areas are increasingly producing rice

Major crops produced are rice, cassava, yam, maize, sorghum, millet and groundnut. The country is self-sufficient in most basic staples such as cassava and yam, but it is still heavily dependent on import of processed agricultural products, particularly rice, wheat, sugar, livestock products and fish (FMWR, 2014). The main agricultural exports are cocoa, nuts and sesame. Livestock in 2011 consisted of 19.5 million cattle, 72.5 million goats, 41.3 million sheep, 7.1 million pigs, 158 million poultries, 0.97 million donkeys and 28 000 camels.

Nigeria achieved the first Millennium Development Goal (1c) of halving the proportion of hungry people by 2015, despite population growth. As a result, the prevalence of undernourishment is 6.4 percent in 2014, down from 21 percent in 1990-92, thanks to agricultural and trade reforms (FAO, 2015).

WATER RESOURCES

The country is well drained with a close network of rivers and streams. Some of these, particularly the smaller ones in the north, are seasonal. There are four principal surface water basins in Nigeria (Table 2), the Lake Chad basin being the only internal drainage basin in the country.

TABLE 2
Nigeria's main surface water basins

Surface water basins	Area (km^2) *	% of total country area	Main rivers
Niger basin	584 193	63	Niger and its tributaries (Benue, Sokoto and Kaduna)
Lake Chad basin	179 282	20	Komadougou Yobe and its tributaries (Hadejia, Jama'are and Komadougou Gena)
South-western littoral basins	101 802	11	Rivers from the hilly area south and west of the Niger river
South-eastern littoral basins	54 493	6	Cross, Imo

* The total area is 919 770 km^2, slightly different from the official total area of the country of 923 770 km^2

For the purpose of water resources management, Nigeria is divided into eight hydrological areas (HA), considering hydrological and topographical conditions (Table 3).

TABLE 3
Nigeria's hydrological areas (HA)

Hydrological areas		Area (km^2) *	Precipitation (mm/year)	Main related RBDAs **	Main related states
HA-1	Niger North	135 100	767	Sokoto-Rima	Katsina, Samfara, Sokoto, Kebbi
HA-2	Niger Central	154 600	1 170	Upper Niger, Lower Niger	Niger, Kwara, Kaduna, Kogi, Federal Capital Territory
HA-3	Upper Benue	156 500	1 055	Upper Benue	Adamawa, Taraba, Gombe, Bauchi
HA-4	Lower Benue	74 500	1 341	Lower Benue	Plateau, Nassarawa, Benue, Kogi
HA-5	Niger South	53 900	2 132	Anambra-Imo, Niger Delta	Bayelsa, Delta, Edo, Kogi, Anambra, Rivers
HA-6	Western Littoral	99 300	1 541	Ogun-Osun, Benin-Owena	Lagos, Ogun, Oyo, Osun, Ondo, Edo, Ekiti
HA-7	Eastern Littoral	57 400	2 106	Cross River	Abia, Anambra, Imo, Enugu, Ebonyi, Cross River, Akwa Ibom, Rivers
HA-8	Lake Chad	178 500	610	Hadejia-Ja'mare, Chad	Kano, Jigawa, Yobe, Borno, Bauchi, Plateau, Adamawa

* The total area is 909 800 km^2, slightly different from the official total area of the country of 923 770 km^2

** RBDA = River Basin Development Authority

The Niger river flows from Benin into Nigeria in south-easterly direction. A major tributary in Nigeria is the Benue river, which joins the Niger river near Lokoja. Then the Niger river flows southwards to the Gulf of Guinea through the Niger Delta. Its discharge in the ocean combines two types of flow during the year. Around March-April, the discharge reflects mostly the inflow from Niger with the peak occurring almost half year after the precipitation event in the upper Niger river because of the inland delta in Mali. The runoff in the lower reach almost coincides with the precipitation season with the peak around August-September.

Nigeria has extensive groundwater resources:

- Sokoto basin: sedimentary rocks in northwest Nigeria
- Chad basin: sedimentary rocks in northeast Nigeria, with three distinct aquifer zones: upper, middle, lower
- Middle Niger basin: sandstone aquifers and the alluvium in the Niger Valley
- Benue basin: a sandstone aquifer and the least exploited aquifer in Nigeria, extending from the Cameroon border in the east to the Niger-Benue confluence
- Southwestern zone: sedimentary rocks, bounded in the south by the coastal alluvium and in the north by the basement complex
- South-Central zone: Cretaceous and Tertiary sediments centred on the Niger Delta
- Southeastern zone: Cretaceous sediments in the Anambra and Cross river basins; borehole numbers are low due to abundant surface water resources
- Basement Complex: represents over 60 percent of the country's area; it consists of low permeability rocks and groundwater occurs in the weathered mantle and fracture zones

Low-lying areas flooded during the wet season, known as *fadama* areas, are scattered across the ecological zones of Guinea Savanna, Sudan Savanna, and the Sahel. These diverse wetlands are valuable for grazing, agriculture and municipal uses, and are of international importance as breeding grounds for migratory birds, thereby having a global value for biodiversity. Flood plains cover over 515 000 ha and 11 sites are declared Ramsar sites for a total area of 1 076 728 ha in 2013. The main wetlands are the Lake Chad wetlands in Nigeria lying in the semi-arid Sahel corridor (> 600 000 ha), the Lower Kaduna-Middle Niger Floodplain (> 200 000 ha) and the Baturiya Wetland (> 100 000 ha) (Ramsar, 2013).

Long-term average internal renewable surface water resources are estimated at 214 000 million m³/year and renewable groundwater resources at around 87 000 million m³/year, but 80 000 million m³/year is considered to be overlap between surface water and groundwater, which gives a value of total internal renewable water resources (IRWR) of 221 000 million m³/year (Table 4). External water resources are estimated at 65 200 million m³/year, which is the inflow from the Niger basin from Niger (32 400 million m^3/year) and from Benin (3 800 million m^3/year), as well as the Benue river and its tributaries from Cameroon (29 million m^3/year). Surface water leaving the country to other countries is estimated at 2 900 million m³/year, of which 200 million m^3/year through the Maradi river to Niger and 2 700 million m³/year through the Komadougou Yobé river to Chad. The dependency ratio is 23 percent and the long-term average annual total renewable water resources are 286 200 million m³/year, or 1 571 m³/year per capita in 2015.

TABLE 4
Water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	1 150	mm/yr
	-	1 062 000	million m^3/yr
Internal renewable water resources (Long-term average)	-	221 000	million m^3/yr
Total renewable water resources	-	286 200	million m^3/yr
Dependency ratio	-	23	%
Total renewable water resources per inhabitant	2015	1 571	m^3/yr
Total dam capacity	2015	50 667	million m^3

Annual exploitable groundwater resources are estimated at about 59 510 million m^3, distributed as follows: 10 270 million m^3 in the north, 25 480 million m^3 in the Middle Belt and 23 760 million m^3 in the south.

Currently, there are 264 existing dams in Nigeria (FMWR, 2013). Cumulated capacity of larger dams is estimated at 50 667 million m^3. The main dams, such as Kainji, Jekara and Jebba, are associated with large hydropower generation plants. The average effective storage is about 78 percent of the total storage capacity. There are about 30 dams under construction for an additional capacity of 1 600 million m^3 and plans for the development of 10 000 million m^3 by 2020, in addition to the rehabilitation of 50 existing dams (FMWR, 2014). These figures do not include the controversial Dasin Hausa dam, with an expected capacity of 16 000 million m^3, which was planned together with the Lagdo dam in Cameroon operational since 1982 (see "International water issues" below).

No data is available regarding the volume of wastewater produced, collected and treated, but most of it finds its way back to water bodies without any treatment. There is a very limited volume of desalinated water produced. A project of brackish water desalination with a capacity of 73 million m^3/year is currently being developed in Lekki Lagos.

INTERNATIONAL WATER ISSUES

Main transboundary rivers flowing into Nigeria are the Niger river, flowing from Benin and Niger, and the Benue river, flowing from Cameroon, which joins the Niger river at Lokoja at approximately 400 km north from the estuary. Nigeria also shares Lake Chad with Niger, Cameroon and Chad (Table 5). In addition to being part of the Niger Basin Authority and the Lake Chad Basin Commission, Nigeria is also part of two binational joint commissions. The Nigeria-Niger Joint Commission initiated the Maiduguri Agreement signed on 18 July 1990, and amended 5 October 1998, dealing with development, conservation and utilization of the water resources of the Komadougou-Yobe sub-basin in particular. The Cameroon-Nigeria Mixed Commission was established after Lake Chad receded in order to settle the conflict over the blurred border between the two countries. A protocol to exchange daily data on flows, especially release from the Lagdo dam, and coordinate large infrastructures was also signed with Cameroon.

TABLE 5
Transboundary basins

Basin	Total basin area (km^2)	Shared with	International management structure
Niger	2 090 000	Algeria, Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger	Niger Basin Authority (NBA) created in 1980, which is the successor of Niger River Commission, created in 1964
Lake Chad	2 400 000	Cameroon, Central African Republic, Chad, Niger	Lake Chad Basin Commission (LCBC) created in 1964

There are issues with these transboundary basins, mostly associated with the development of dams in the upstream countries Niger and Cameroon:

- The Kandaji dam, under construction since May 2012 on the Niger river in Niger, will have a capacity of 1 600 million m^3. The constant release of 120m^3/s will be beneficial for improving the flow condition in the Niger river in dry season. However, if the water stored behind the dam will be used for irrigation in Niger in the future, the total inflow into Nigeria will be somehow reduced.
- The Lagdo dam, constructed in 1982 on the Benue river in Cameroon, has a capacity of 8 000 million m^3. It is located about 100 km upstream of the Nigerian border. No protocol for downstream users was adopted before construction. Since its operation siltation of the river bed and water infrastructures downstream in Nigeria increased and some *fadama* cultivation in eastern Nigeria was lost. On the other hand it also controls floods and improves the river environment thanks to continuous release of a minimum flow, especially during dry season. But

the sudden water release during flood in 2012 may have caused greater damages around Yola near the Benue river in Nigeria, 50-100 km downstream the border with Cameroon (FMWR, 2014).

Transboundary groundwater is limited in sedimentary rock area. In four of the hydrological areas (HA) of Table 3 transboundary groundwater flow exist: Sokoto (HA1), Upper Benue (HA3), Western Littoral (HA6) and Lake Chad (HA8).

WATER USE

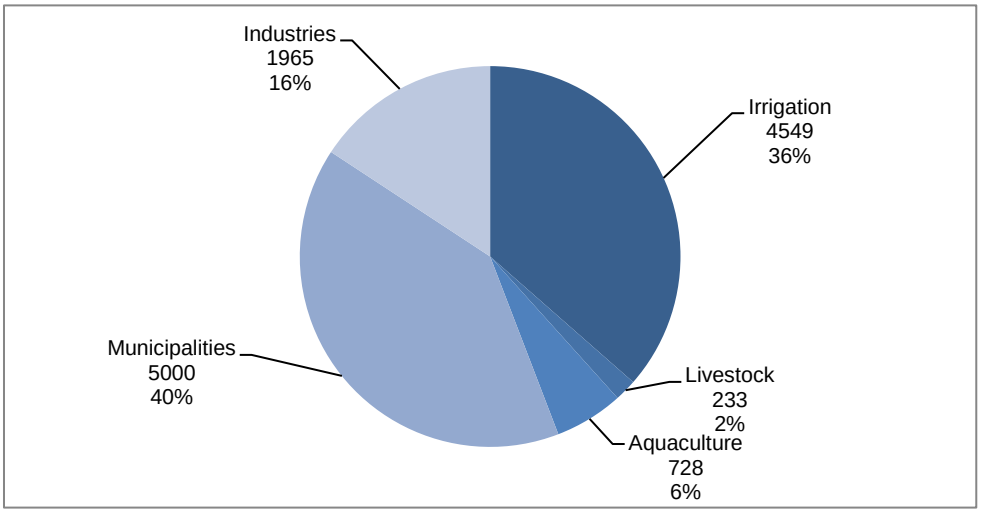
Total annual water withdrawal was estimated at 12 475 million m^3 for the year 2010. Agriculture is the sector withdrawing the largest share of water, with about 5 510 million m^3 (44 percent) made up of 4 549 million m^3 for irrigation, 233 million m^3 for livestock and 728 million m^3 for aquaculture. The latter sub-sector saw a strong development in recent years. Estimations are based on irrigation water requirements and cropping patterns. Municipalities' water withdrawal is estimated at 5 000 million m^3, or 41 percent of the total water withdrawal. Around three quarter of the municipal water withdrawal is from groundwater resources, the remaining coming from surface water. Industry is the sector with the smallest withdrawal with 1 965 million m^3 (14 percent) (Table 7 and Figure 2).

TABLE 6
Water use

Water withdrawal:			
Total water withdrawal	2010	12 475	million m^3/year
▪ Irrigation	2010	4 549	million m^3/year
▪ Livestock	2010	233	million m^3/year
▪ Aquaculture	2010	728	million m^3/year
▪ Municipalities	2010	5 000	million m^3/year
▪ Industry	2005	1 965	million m^3/year
• Per inhabitant	2010	78	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2010	12 475	million m^3/year
• As % of total renewable water resources	2010	4.4	%
Non-conventional sources of water:			
Produced municipal wastewater		-	million m^3/year
Treated municipal wastewater		-	million m^3/year
Direct use of treated municipal wastewater		-	million m^3/year
Direct use of agricultural drainage water		-	million m^3/year
Desalinated water produced		-	million m^3/year

Note: The figures in this table refer to water demand and not water withdrawal

FIGURE 2
Water withdrawal by sector
Total 12 475million m^3 in 2010



About 41 percent of the water demand is expected to be met from surface water source and 59 percent from groundwater source. Groundwater is available and used in the whole country for all types of uses–water supply, private irrigation, livestock, aquaculture and industries–either in the Basement Complex area, where depth of boreholes is 50m in average for a 10 to 150 m^3/day yield, or from sedimentary rock area with deeper boreholes with larger yields (50 to 400 m deep for 10 to 500 m^3/day). There are about 64 500 boreholes in Nigeria, of which 57 600 are for public water supply. Motorized and hand pumps are installed into boreholes, but only 63 percent of boreholes are functional due to breakdown of pumps. Groundwater withdrawal is estimated at about 2.3 million m^3/year (FMWR, 2014).

IRRIGATION AND DRAINAGE

Evolution of irrigation development

Irrigation potential estimates in Nigeria vary from 1.5 to 3.2 million ha. The latest estimate gives a total of about 2.3 million ha, of which over 1 million ha are in the north (WB, 2014).

Traditional irrigation dates back to the 9th century. Until recently, the majority of irrigation was located in naturally flooded swamps, or *fadamas*, usually controlled with simple mud bunding. *Fadamas* are lowlands, flood plains or valley bottoms with a high water table. The traditional dry season farming in northern Nigeria was practiced in the valley of the Komadougou Yobe along the border with Niger and on the swampy area of Lake Chad and was dominated by simple lift systems (*shadufs* replaced by pumps in the 1970s). Flood-recession cultivation was possible in the Lake Chad region, although it has never become widespread. In the early 1950s, some rice schemes and simple flood control schemes were created in the Niger State in the centre-west of the country (Blench, 1993). Public irrigation was initiated only in the 1970s, during the oil boom and following a strong drought in 1970-75. The three pilot irrigation schemes developed in the early 1970s, Bakolori in the northwest, Kano in the north and Chad basin in the northeast, were successful. Hence, substantial investment was made by the government during the 1970-80s, especially in dams. However, the corresponding irrigation infrastructure was often not developed due to economic reform made in the late 1980s aiming at economic efficiency and higher productivity, resulting in budget reduction for public irrigation infrastructure development. At the same time, agricultural development projects (ADPs) were designed to develop small-scale, farmer-based, privatized irrigation systems in *fadama* lands for wheat and vegetable cultivation especially during the dry season by providing pumps and tubewells. The National Fadama Development Project (NFDP) built on the ADPs' achievements from 1993 onwards.

The area equipped for irrigation in 2004 was 293 117 ha, comprising 238 117 ha full control irrigation and 55 000 ha of equipped lowlands, i.e. improved *fadamas*. About 75 percent, or 218 840 ha, of the equipped area was actually irrigated in 2004.

In 2010, the area equipped for irrigation increased to 325 106 ha, of which 232 106 ha are full control irrigation and 93 000 ha equipped wetlands (FMWR, 2014; Table 7 and Figure 3). The area equipped for full control irrigation can be classified into:

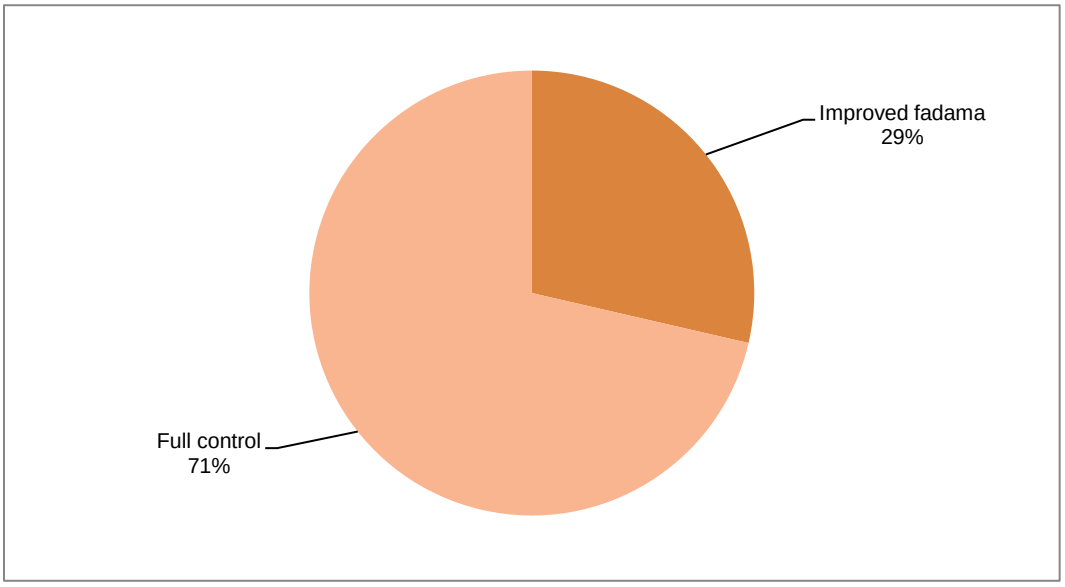
- Public schemes using mainly surface water on 142 106 ha, of which only about 40 percent is actually irrigated (FMWR, 2014)–32 percent for irrigated areas managed by RBDAs and 55 percent for those managed by States (AfDB, 2013). This low rate is due to the need for rehabilitation in most schemes–for 80 percent of the equipped area–, high operation and maintenance costs, fuel shortage or deterioration of the infrastructures and pumps from a technical perspective. The lack of coherent irrigation policy, inadequate support services, low level of ownerships by the farmers and uncertain financial viability also explain the low operational level.
- Private schemes on about 90 000 ha, of which 70 percent is actually irrigated. Almost all of them being small-scale (< 50 ha) and use groundwater. Only two private companies have larger irrigation schemes, mostly to produce sugar cane and vegetables, but out of

the 7 000 ha equipped for irrigation in Savannah sugar estate only 500 ha were cropped and irrigated in 2004 (FMWR, 2014).

TABLE 7
Irrigation and drainage

Irrigation potential			2 330 510	ha
Irrigation:				
1. Full control irrigation: equipped area		2010	232 106	ha
- Surface irrigation			-	ha
- Sprinkler irrigation			-	ha
- Localized irrigation			-	ha
• Area equipped for full control irrigation actually irrigated		2010	133 000	ha
- As % of area equipped for full control irrigation		2010	57	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		2010	93 000	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2010**	**325 106**	**ha**
• As % of cultivated area		2010	0.8	%
• % of area irrigated from surface water			-	%
• % of area irrigated from groundwater			-	%
• % of area irrigated from mixed surface water and groundwater			-	%
• % of area irrigated from non-conventional sources of water			-	%
• Area equipped for irrigation actually irrigated			-	ha
- As % of total area equipped for irrigation			-	%
• Average increase per year		2004-2010	1.7	%
• Power irrigated area as % of total area equipped for irrigation			-	%
4. Non-equipped cultivated wetlands and inland valley bottoms			-	ha
5. Non-equipped flood recession cropping area		2010	681 914	ha
Total water-managed area (1+2+3+4+5)		**2010**	**1 007 020**	**ha**
• As % of cultivated area		2010	2.5	%
Size of full control irrigation schemes:	**Criteria**:			
Small schemes	< 50 ha	2010	90 000	ha
Large schemes	> 50 ha	2010	142 106	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes:				
Total irrigated grain production			-	metric tons
• As % of total grain production			-	%
Harvested crops:			-	
Total harvested irrigated cropped area			-	ha
• Temporary crops: total			-	ha
• Permanent crops: total			-	ha
Irrigated cropping intensity (on full control area actually irrigated)			-	%
Drainage - Environment:				
Total cultivated area drained			-	ha
• Non-irrigated cultivated area drained			-	ha
• Area equipped for irrigation drained			-	ha
- As % of total area equipped for irrigation			-	%
Area salinized by irrigation		1999	100 000	ha
Area waterlogged by irrigation			-	ha

FIGURE 3
Areas equipped for irrigation
Total 325 106 ha equipped for irrigation in 2010



In addition, non-equipped flood recession cropping was being practiced on 681 914 ha, bringing the total water-managed area to 1 007 020 ha in 2010. Traditionally many farm families in Nigeria had cultivated small areas in *fadamas* during the dry season, using water manually drawn from shallow wells or streams. Major *fadama* areas are located along the flood plains of the Niger, Sokoto Rima, Benue and Yobe rivers.

Role of irrigation in agricultural production, the economy and society

With irrigated land being less than 1 percent of the cultivated area, the contribution of irrigated agriculture to total crop production is small. The impact of irrigation is felt only with regard to specific crops such as wheat, sugarcane and to some extent rice and vegetables. In the 2003-2004 season irrigated grain production contributed to 0.9 percent of the total grain production and irrigated vegetable production contributed to 2.3 percent of the total vegetable production. The main irrigated crops in 1999 were vegetables, wheat, maize and sugarcane. Other irrigated crops were rice, potatoes, cotton, cowpeas, oil palm, citrus fruits, cocoa, rubber, taro and cashew nuts. The crop with the highest increase in net return resulting from irrigation is sugarcane, due to a four-fold per hectare yield increase. Next are onions and tomatoes, the least profitable crops being rice and wheat.

Productivity of irrigated agriculture is negatively impacted both by land fragmentation–in schemes and in *fadamas*–and under-utilization of large dams in particular in the North where most dams and irrigation infrastructures are located. This under-utilization resulted in large irrigation schemes becoming unsustainable physically, environmentally and financially and non-functional schemes have reverted back to rainfed cultivation. This situation makes irrigated agriculture uncompetitive and unattractive, thereby discouraging potential investors and youths to participate in irrigated agriculture (FMWR, 2013). In 2010-2011, 2.8 percent of farm household plots were irrigated and only 1.6 percent the following year (NBS, FMARD and WB, 2014). Irrigation is most common in the northwest with 6 percent of plots reported as irrigated compared to 1.3 percent in the southwest in 2010-2011 with slightly higher rate of plots being irrigated in the urban than in the rural areas (NBS, FMARD and WB, 2013).

Crops cultivated in public irrigation schemes are diverse, including rice, maize, tomatoes and other vegetables. However, rice generally constitutes the major crop cultivated in the rainy season. Irrigated rice is with 510 050 ha nevertheless less common than rainfed upland and lowland rice together with 1 243 151 ha and 47 799 ha in 2008 respectively (FMWR, 2014). However, irrigated rice has the highest yield with 3.5 tons/ha, which is almost double the rainfed rice yield (1.7 tons/ha for rainfed upland rice

and 2.2tons/ha for rainfed lowland rice) (Ugalahi, 2016). High irrigated rice yields are obtained in some public irrigation schemes. For example, the Bakolori irrigation scheme, one of the largest schemes in the country with over 5 000 ha actually irrigated and almost 19 000 registered farmers in 2014, experiences yields comparable to Asian rice with 5.4 tons/ha during the dry season and 4.6 tons/ha during the rainy season (IFPRI, 2015).

Irrigated agriculture reduces poverty as demonstrated by a study of the role of Kampe irrigation dam in Kogi State, where the poverty incidence reduced to 41 percent for beneficiaries of irrigation projects compared to 57 percent for non-beneficiaries in the same community (Gbenga, 2015).

Women and irrigation

Women do most of the water fetching in low-income urban areas, as they do in rural areas. They, together with children, are also the most affected by floods especially in the lower Niger river, since their share of the workload for most of the farming tasks is larger than the men's share, in addition to doing most of the water fetching. They are thus more exposed to the flow release from upstream dams (Atakpu, 1999).

In 2007, out of the 15.7 million agricultural holders in Nigeria, 10 percent were women. Women nonetheless provide 70 percent of the agricultural workload and 90 percent of the animal husbandry workload and they also play a major role in producing, processing and marketing food crops. This is because under customary law, women rarely inherit land and primarily obtain use rights through their husbands. Although statutory law says women are entitled to inherit in the same way as men, this law applies only to women who are married under statutory law and only if there is a will. Furthermore, under both statutory and customary systems, land registration is usually in the man's name. Ninety percent of registered land and properties are in men's names. Less than 14 percent of women have land in their name. They also have limited access to agricultural inputs such as fertilizer, improved seedlings and agricultural extension services. Indeed male-headed households use considerably more inputs, except seeds, than female-headed households. Only 15 percent of beneficiaries of government programmes are women (FAO, 2016). Male-headed household plots are also more likely to be irrigated than plots cultivated by female-headed households: 3 percent of the former are irrigated against 1.3 percent of the latter in 2010-2011 (NBA and WB, 2013). These figures drop to 1.8 percent and nil respectively in 2011-12 (NBS, FMARD and WB, 2014).

The culture in some of the northern states prevents married women from direct participation in farming. Where culture practices are enforced strictly, so that married women cannot engage directly in *fadama* farming, they cultivate land they may inherit or purchase by using the labour of their husbands, friends, other male relatives or hired workers. This presents a cost disadvantage to such women as all *fadama* cultivation involves relatively high labour inputs. In some communities there is a belief that *fadama* farming is too complicated for women and women are excluded from the more productive aspects of farming.

Decision-making at household level is not very different between men and women. However, at the community level, female participation in decision-making is much lower than their male counterpart – 1.7 percent and 17.4 percent respectively (AfDb, 2013).

Status and evolution of drainage systems

Most large-scale irrigation schemes in Nigeria are fully equipped with drainage networks. For instance, in the Kano River Irrigation Project I the total area of 15 000 ha equipped with irrigation canals has a corresponding drainage network. This also applies to Bakolori Irrigation Project, South Chad Irrigation Project, Kiri Irrigation Project, Bagwai Irrigation Project, Lower Anambra Irrigation Project and Hadejia Valley Irrigation Project for example. Most is surface drainage. Subsurface drainage is not very common in the country, except in the irrigation schemes of the Savannah Sugar and Bachita Sugar Companies. However, most of the surface drainage networks are not operational due to encroachment by landless

farmers, weed infestation, cattle crossing, tractor crossing during seedbed preparation for dry and wet season cropping, etc. Combined with poor on-farm water management practices, waterlogging and salinization appeared in of some irrigated fields (FMWR, 2015).

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

The Federal Ministry of Water Resources (FMWR) is the main national coordinating body in the water sector. The present FMWR was established in 2010, but inherited directly from the Water Resources Division established in the 1960s within the Federal Ministry of Agriculture (FMA). Merges and divisions between the FMWR and FMA have been frequent since then. Four of the eight FMWR departments are directly concerned with irrigation subsector matters:

- The Department of Irrigation and Drainage (DID): among its major responsibilities are the supervision and monitoring of the River Basin Development Authorities (RBDAs)
- The Department of Planning, Research and Statistics
- The Department of Hydrology and Hydrogeology
- The Department of Dams and Reservoir Operations

The FMWR is also responsible for 16 parastatals agencies:

- The 12 River Basin Development Authorities (RBDAs), established progressively between 1973 and 1984, play an important role in water resources development, dam construction, irrigation and water supply, operation and management of the public irrigation within the authorities' areas:
    - Anambra-Imo River Basin Development Authority (AIRBDA)
    - Benin Owena River Basin Development Authority (BORBDA)
    - Chad Basin Development Authority (CBDA)
    - Cross River Basin Development Authority (CRBDA)
    - Hadejia Jama' Are River Basin Development Authority (HJABDA)
    - Lower Benue River Basin Development Authority (LBRBDA)
    - Lower Niger River Basin Development Authority (LNRBDA)
    - Niger Delta Basin Development Authority (NDBDA)
    - Ogun-Osun River Basin Development Authority (OORBDA)
    - Sokoto-Rima River Basin Development Authority (SRRBDA)
    - Upper Benue River Basin Development Authority (UBRBDA)
    - Upper Niger River Basin Development Authority (UNRBDA)
- The Nigeria Hydrological Services Agency (NIHSA) created in 2010.
- The Nigeria Integrated Water Resources Management Commission (NIWRMC), created in 2007, is a central coordinating body for the 8 Catchment Management Offices of the 8 hydrological areas (HA listed in section "water resources" and Table 3).
- The National Water Resources Institute (NWRI) established legally in 1985, but began to operate as a training centre on water resources in 1979.

Other federal institutions involved in the irrigation subsector are:

- The National Council of Water Resources (NCWR) is the most important water policy formulating body. Its sub-committee, the National Technical Committee on Water Resources (NTCWR) ensures information exchanges between federal and state level agencies.
- The Federal Ministry of Agriculture and Rural Development (FMARD), formerly involved in irrigation development through the Agricultural Development Projects (ADPs) in particular,

provides extension services to the public sector irrigation schemes of the RBDAs and the State Irrigation Departments.
- The Federal Ministry of Environment (FMEnv) is responsible for setting up policies on water quality, sanitation and pollution control including water quality standards and guidelines.

The current institutional arrangement presents some overlaps, for example between the FMEnv and the FMWR's Department of Water Supply (FMWR, 2014).

At the State level, agencies involved in the irrigation subsector are:

- State Ministries of Water Resources (SMWRs) in some States, which host the State Irrigation Department (SID) transferred from the State Ministry of Agriculture.
- State Ministry of Works, which is responsible for water resources development in particular in States without a SMWR.
- State Ministries of Agriculture (SMAs), which were responsible for irrigation development before RBDAs were established. They host the SID, in case there is no SMWR.
- State Water Agency (SWA), which is usually responsible for drinking water supply and sanitation (FAO, 2013).

Water management

Public irrigation in the Nigerian context means schemes run either by River Basin Development Authorities (RBDAs) or by the States. A farmer group in each scheme is supporting the maintenance of irrigation facilities. And for example, in the Bakolori irrigation scheme, collective action on canal and drainage maintenance is relatively common and was often initiated by the irrigators themselves (IFPRI, 2015). However, the infrastructures are in most cases in dire need of rehabilitation with non-functional pumps, damaged or silted up canals. Non-equipped water managed areas are effective due to their low maintenance. Many of the public small schemes in the south of the country are effectively operational whilst some of the public large schemes are still active but operating at low capacity level and low cropping intensity (FMWR, 2014).

The National Fadama Development Project (NFDP) resulted in the formation of more than 9 000 Fadama User Associations (FUAs). And government policy is to subdivide schemes along the lines of one Water User Association (WUA) per distribution canal; thus, a WUA comprises 10-25 farmers. Responsibilities include operation and maintenance (O&M) of the canal and its structure and adherence to water scheduling programmes. WUAs have traditionally been weak from design to operation and maintenance of irrigation projects. They rarely are effective or active in most schemes.

Between 2006 and 2013 it became clear that that irrigation development did not progress as planned, that farmers did not get reliable delivery of irrigation water and that irrigated production sometimes decreased. So FMWR signed in 2014 a delegation of authority for large-scale public schemes to transfer tertiary irrigation and drainage facilities to WUAs. The WUAs Federations (WUAFs) will be in charge of O&M at tertiary and field level, and the collection of water charges, as soon as the new Water Bill has been passed.

Although for commercial use a license for water abstraction and use is required according to the *1993 Water Resources Act*, it has not yet been implemented. As a result, either water is withdrawn without a license, even by governmental agencies, or a contract between the agency and the RBDA is considered to be a license (FMWR, 2014).

Finances

Only from 1983 onwards, a token irrigation water charge was requested to farmers. The water charge paid in most of public irrigation schemes is on average US$ 10/ha per season, while operation and

maintenance (O&M) costs are estimated at US$61/ha/year for gravity-fed schemes and US$530/ha/year for schemes using pumps. The water charges are too low to meet the cost of water delivery. In most cases, charges were never collected and when they were, collection rate was weak. The Federal and State governments played a significant role in O&M expenses (FMWRRD, 1995), considering water supply as a social service (Brebbia and Bjornlund, 2014). But with economic reforms, it resulted in infrastructure deterioration and low level of productivity, requiring rehabilitation. The inadequate pricing is responsible for the cycle of poor services leading to lack of willingness to pay by the user (FMWR, 2014).

Policies and legislation

The main legislation regarding water management is the *1993 Water Resources Act* No. 101 giving the FMWR significant power to control and coordinate activities for proper watershed management and resources protection and for public administration of water resources. A new *National Water Resources Bill* was drafted from October 2006 and will replace the *1993 Water Act*, as soon as it is enacted by the National Assembly–still pending by mid-2016. It is based on the 2009 revised National Water Policy and includes principles of integrated water resources management and stakeholders' participation.

In addition to the *1993 Water Resources Act*, the following legislations also affect the water sector:

- *The 1986 River Basins Development Authorities Act (No. 35)*
- *The 2000 Niger-Delta Development Commission (Establishment, etc.) Act*
- *The 2011 Nigeria Integrated Water Resources Management Commission (NIWRMC) Act* (passed by the National Assembly but never assented by the President).

To complement these legislations, the following policies and strategies in relation with water apply in Nigeria:

- The Water Resources Strategy 2006
- The Draft National Irrigation Policy and Strategy (NIDPS) 2006
- The Draft Policy on Private Sector Participation in Irrigation Development and Management
- The National Water Resources Policy 2009 (Revised from 2004): principles and strategies for the development and management of water resources by the FMWR.
- The Water Sector Roadmap 2011

More generally, the federal government launched an Agriculture Transformation Agenda (ATA) in 2011 to promote productivity growth.

ENVIRONMENT AND HEALTH

Soil degradation

Desertification is by far the most pressing environmental problem in the northern states along the border with Niger. Nigeria is presently losing about 351 000 km^2 of its land mass to the desert which is advancing southward at the rate of 0.6 km/year.

Soil degradation is induced by human activities, such as:

- Urban encroachment due to overpopulation, where some farmlands have been converted into urban areas; concentration of intensive agriculture around urban centres exacerbates degradation of land and water resources.
- Deforestation due to uncontrolled land clearings for construction or agriculture purposes.
- Inappropriate use of agro-chemicals and the concomitant problems of chemical persistence in the soil in humid areas and soil-crust formation in arid climates, which have contributed to

salinization and destruction of vast agricultural lands. The coastal areas of Nigeria are heavily affected by salinization.

Loss of water bodies and lowlands

Hydrology downstream from dams and major diversions and pumping stations has been modified, especially in the north. Extensive areas of *fadama*, fisheries and wildlife habitats were wiped out.

The Hadejia Nguru Wetlands in the northeast of the country receive their water from the Hadejia and Jama'are rivers, which meet to form the Komadougou Yobe river, flowing northeast into Lake Chad. So far, more than half of the wetlands have been lost due to drought and upstream dams. New development could divert still more water from the wetlands for irrigated agriculture in upstream areas, affecting both the ecology and the irrigated agricultural production in the floodplain using water from the shallow groundwater aquifer, as recharging would decrease further.

Inappropriate agricultural practices, such as lack of crop rotation, adoption of maximum tillage, inadequate or total lack of fallowing, inadequate fertilization, overgrazing, absence of mulching, and the opening up of riverbanks have led to silting of riverbeds and loss of watercourses.

Groundwater overexploitation and quality

Expansion of irrigated crop production in the *fadama* lands has led to a lowering of the water table in some areas. Overexploitation of groundwater starts to be felt in some areas also for industrial and municipal use due to the non-enforcement of controlled drilling. In the northern areas, it could build-up salinity and in the southern parts, salt-water intrusions are threatening due to the lowering of the groundwater table, as it is already the case in metropolitan areas such as Lagos and Port Harcourt, located in the coastal plains.

The quality of the groundwater is generally good. The occurrence of iron rich water in the Niger Delta can sometimes constitute a major problem in some isolated localities in the dry deltaic plains (AfDB, 2013).

Surface water quality

Wastewater treatment is almost inexistent, so most of the wastewater reaches water bodies without any treatment. The water quality of rivers is strongly influenced by human activities especially when passing through urban, industrial and agricultural areas. Generally, the water quality of rivers is good in the southern areas, but in the northern areas water quality decreases in the dry season with low flows.

In the Niger Delta, water resources are being polluted from oil exploration activities such as oil drilling and pipe leakages and vast farmlands have been destructed.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Poor operation and maintenance of irrigation infrastructures, results in deterioration of water delivery and low performances in already ageing irrigation schemes. In addition, enforcement of water legislation is weak, institutions' mandates are overlapping, irrigators do not participate in decision-making, and lack of extension services leads to poor on-farm water management practices. As a result, development of irrigated agriculture in the country has been very slow and behind planned development.

The 1995 National Water Resources Master Plan (NWRMP) planned an additional 800 000 ha equipped for irrigation by 2020 to bring the total area equipped for irrigation at 1 500 000 ha, of which 1 120 000 ha public irrigation and 380 000 ha private irrigation. The new irrigation development plan of the

updated 2014 NWRMP revised these targets with 468 752 ha of public irrigation and 335 000 ha of private irrigation, i.e. a total of 803 752 ha equipped for irrigation by 2030 (FMWR, 2014).

Achievement of these targets should first take advantage of the already existing infrastructures, both dams and irrigation schemes. Some storage dams, such as Dadin Kowa dam for example, are still in good condition, but nonetheless abandoned (WB, 2014). This is also the case for some irrigation schemes where the actually irrigated areas are far less than the developed area. The objective in 2013 is to increase the then 32 percent of equipped area actually irrigated under River Basin Development Authorities (RBDAs) management, and 55 percent under State government management, to 70 percent and 80 percent respectively by 2017 (AfDB, 2013b). However, in most cases dams and irrigation schemes require rehabilitation that would increase the water storage capacity and irrigation performances. New water storage infrastructures are also considered to allow for the planned irrigation targets.

The projected water demand by 2030 for agriculture, industries and municipalities is 16 584 million m^3, of which for municipalities 8 852 million m^3 (53 percent), for irrigation 6 245 million m^3 (38 percent), for aquaculture 1 166 million m^3 (7 percent) and for livestock 321 million m^3 (2 percent). Almost half of this demand could be supplied by groundwater resources, while the remaining would be by surface water resources (FMWR, 2014).

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