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Libya

GEOGRAPHY, CLIMATE AND POPULATION

Geography

Libya has a total area of about 1.76 million km². It is bordered in the north by the Mediterranean Sea, in the east by Egypt, in the southeast by Sudan, in the south by Chad and Niger, and in the west by Algeria and Tunisia. Four physiographic regions can be distinguished:

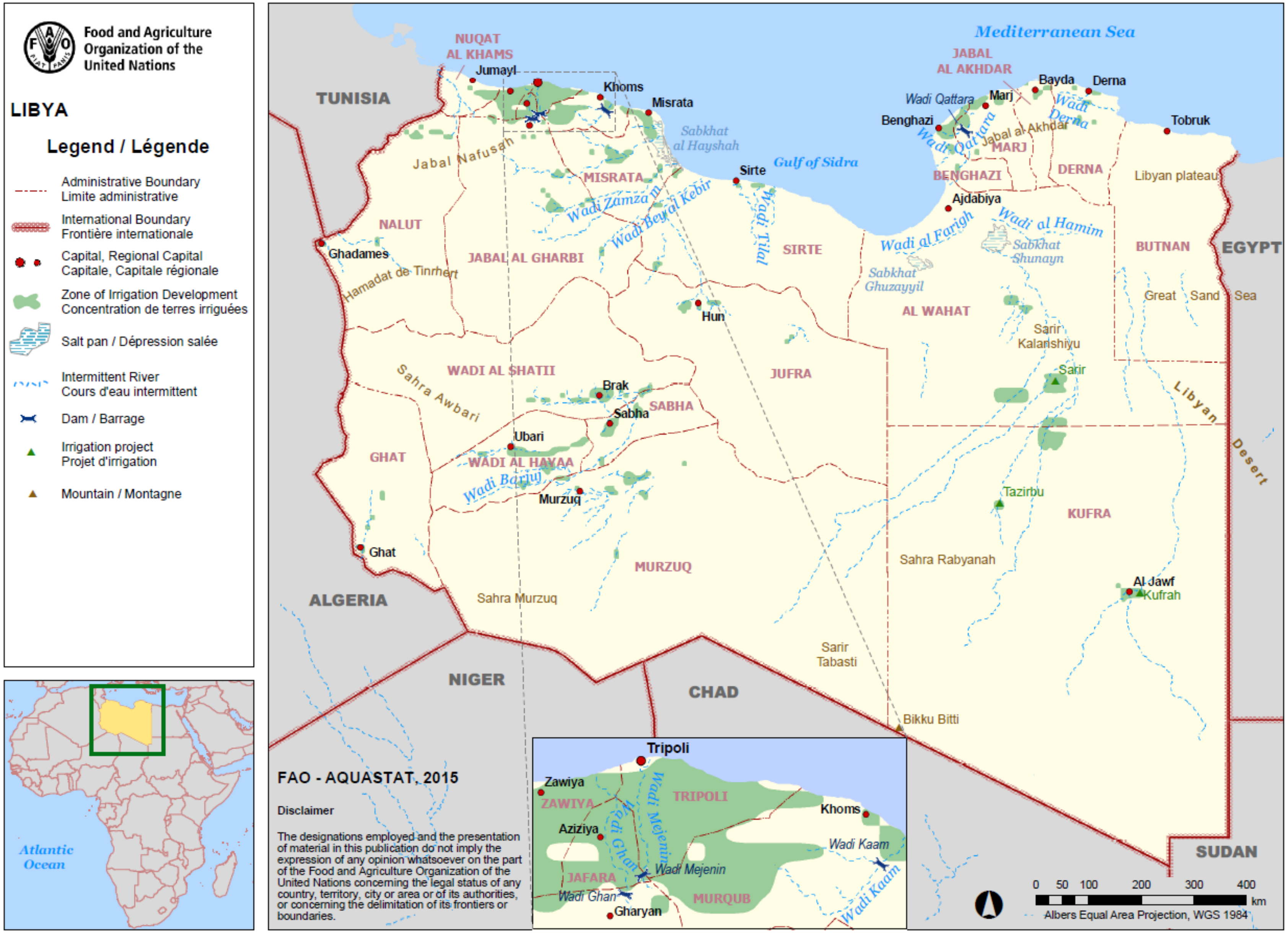
- The coastal plains that run along the Libyan coast and vary in width;
- The northern mountains that run close to the coastal plains and include the Jabal Nafusah in the west and the Jabal al Akhdar in the east;
- The internal depressions that cover the centre of Libya and include several oases;
- The southern and western mountains.

About 95 percent of the country is desert. The cultivated area is estimated at about 2 million ha which is 1 percent of the total area of the country. Permanent pastures account for 13.3 million ha, annual crops for 1.72 million ha and permanent crops for only 0.34 million ha in 2013 (Table 1).

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2013	175 954 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2013	15 355 000	ha
• As % of the total area of the country	2013	9	%
• Permanent meadows and pasture	2013	13 300 000	ha
• Cultivated area (arable land + area under permanent crops)	2013	2 055 000	ha
- As % of the total area of the country	2013	1	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2013	1 720 000	ha
- Area under permanent crops	2013	335 000	ha
Population:			
Total population	2015	6 278 000	inhabitants
- Of which rural	2015	21	%
Population density	2015	4	inhabitants/km^2
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2014	41 119	million US$/year
• Value added in agriculture (% of GDP)	2008	2	%
• GDP per capita	2014	6 550	US$/year
Human Development Index (highest = 1)	2014	0.725	-
Gender Inequality Index (equality = 0, inequality = 1)	2014	0.134	-
Access to improved drinking water sources:			
Total population	2001	71	%
Urban population	2001	72	%
Rural population	2001	68	%

FIGURE 1
Map of Libya



Climate

The climatic conditions are influenced by the Mediterranean Sea to the north and the Sahara desert to the south, resulting in an abrupt transition from one kind of weather to another. The following broad climatic divisions can be made:

- The Mediterranean coastal strip has dry summers and relatively wet winters;
- The Jabal Natusah and Jabal al Akhdar highlands experience a steppe climate with higher rainfall and humidity and low winter temperatures, including snow on the hills;
- Moving southwards to the interior, pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal variations; rain is rare and irregular and diminishes progressively towards zero.

Annual rainfall is extremely low, with about 93 percent of the land surface receiving less than 100 mm/year. The highest rainfall occurs in the northern Tripoli region (Jabal Nafusah and Jifarah plains) and in the northern Benghazi region (Jabal al Akhdar), these two areas being the only ones where the average annual rainfall exceeds the minimum value (250-300 mm) considered necessary to sustain rainfed agriculture. Rainfall occurs during the winter months (October-March), but great variability is observed from place to place and from year to year. Average annual rainfall for the country as a whole is 56 mm. Temperatures vary between over 40ËšC in summer to below zero in winter.

Population

Total population was about 6.3 million in 2015, of which only 21 percent is rural. The annual population growth rate for the period 2005-2015 was estimated at 0.8 percent in sharp decline since the 1980s and 1990s, when it was 4.2 and 2.8 percent respectively (GIA and UNDP, 2008). Immigrants from Arab statesâ€“especially Egyptâ€“and from Sub-Saharan Africa reached over 2 million in the 2000s, representing over one third of the population. One third of the immigrants were female. Half a million had left the country after three months of conflict in 2011. The average population density of about 4 inhabitants/km² varies between 300 inhabitants/km² in the northern coastal regions, being one of the highest population density on arable land, to less than 1 inhabitant/km² in the south. An estimated 85 percent of the population lives in or around the coastal cities, especially the capital Tripoli and Benghazi.

In 2014, the Human Development Index considers Libya as a country with high human development ranking 94 among 188 countries, while the Gender Inequality Index (GII) ranks it 27 among 155 countries, for which information was available (UNDP, 2016). Life expectancy in Libya is almost 72 years in 2013 and the under-five mortality is 13 per 1000 births in 2015, both progressing from 70 years and 32 per 1000 in the 1990s. With no significant distinction between boys and girls, almost all children in 2007 are enrolled in primary education (GIA and UNDP, 2008). Adult literacy is 90 percent in 2013, with a significant difference between female and male (84 versus 96 percent respectively; WB, 2016). Poverty concerns 13 percent of the population in 2003 (GIA and UNDP, 2008). Data about access to safe water and appropriate sewage in the country are conflicting, depending on the sources due to the fact that the definition used for the monitoring of these millennium development goals (MDGs) was different at national level and thus not recognized globally. The only figure recognized dates back to 1992 with 71 percent of the total population having access to safe water, with little difference between rural (68 percent) and urban population (72 percent; JMP, 2015). The share of households relying on public taps from drinking water decreased from 58 percent in 2003 to 44 percent in 2007, probably due to water pollution. There was a corresponding increase in the uptake of wells/boreholes and bottled water as main sources of drinking water. Using this figure of the total population connected to public networks and private wells in 2005, and assuming that well water is protected, the JMP estimated the access to safe water at 88 percent in 2005 (90 and 82 percent respectively for urban and rural population; UNDP, 2010). Access to appropriate sewage network is more largely spread with 95 percent of the population having it in 1995 and 98 percent in 2007 (GIA and UNDP, 2008). According to the 2007 Pan Arab Population and Family Health Project, only 63 percent of households in Libya are connected to a waste liquid disposal network, and 40 percent are using septic tanks. Living conditions and amenities are rudimentary in the south outside oil-exploitation areas (WFP and FAO, 2011).

ECONOMY, AGRICULTURE AND FOOD SECURITY

Libya enjoys large natural geological resources, in particular oil and gas, as well as minerals such as iron, silicate and limestone. The Libyan economy is one of the most oil-dependent in the world. The political changes in 2011 incurred a collapse in political and economic governance with two rival parliaments and some militias controlling the oil production. Hence in 2011, the GDP declined by over 60 percent, but recovered the following year to decline again progressively since then. In 2014, the GDP was US$ 41 119 million (current US$) but was very variable from year to year even before the 2011 events depending on the oil prices. Unemployment affected 26 percent of the active population by 2010 and is unlikely to improve with the dual government as a large share of the population was employed in the public sector (FAO, 2015). Oil rents account generally for half of the GDP, almost 57 percent in 2012 and 44 percent in 2013, and are completed by gas rents, accounting for 6 percent of the GDP in 2008. Services account for almost 20 percent and manufacturing for 4.5 percent in 2008 (GIA and UNDP, 2008). The oil fields are mostly in the desert, with few being offshore.

Agriculture contributed 1.9 percent to the GDP in 2008 (WB, 2016) and was similar in 2010 (WFP and FAO, 2011). It has declined over time as the importance of the oil rose. The sector employs around 6 percent of the active population (GIA and UNDP, 2008). Most agriculturally productive land is limited to a strip along the Mediterranean Sea, where most rain falls. The two main areas of natural farmland are the high coastal plateau of Jabal al Akhdar in the north-east and the fertile coastal plain of Tripolitania and Cyrenaica in the north-west, where irrigation is still vital. There are some oases in the desert where water is available from shallow wells. Wheat and barley are the major cereals grown in the country. Other important crops include olives, grapes, dates, almonds and oranges. The main agricultural products exported are groundnuts, which represented about 50 percent of all agricultural exports. Livestock is also important with poultry (24.8 million estimated in 2008), small ruminants (5.1 million sheep, 1.9 million goats) and cattle (210 000). Only small amounts of meat and dry milk are imported, but the sector relies heavily on subsidized imports of animal feed. There are currently about 170 000 farm holders of which almost 40 percent are full-time farmers. Close to 90 percent of the farms are less than 20 ha and only 1 percent greater than 100 ha (WFP and FAO, 2011).

Pre-2011, the country usually imported 80 percent of its food consumption requirement, and up to 90 percent of its cereals requirements. The main agricultural products imported are wheat flour, maize oil and milk, corresponding to about 40 percent of all agricultural products imported (WFP and FAO, 2011). The civil conflict deteriorated the food security due to destruction of public infrastructure, disruption of social services, internally displaced persons and labour shortage resulting from the massive departure of foreign workers since the conflict, that were working in large part in agricultural activities (FAO, 2015). The Libyan government had an extensive social protection and price subsidies including for food staples, housing and energy (WFP and FAO, 2011).

WATER RESOURCES

With very limited perennial water resources, Libya relies almost completely on non-renewable, fossil, groundwater resources (MWR and CEDARE, 2014). There are no permanent rivers in Libya, only ephemeral rivers or wadis. The main natural lakes are the Ubari lakes in the Ubari Sand Sea in the south, including the Gaberoun, Mandara and Mafo akes–, the protected Ouau en Namu lakes and the 23rd of July or Benghazi lake, which is actually a lagoon. There are two Ramsar sites since 2000: Ain Elshakika and Ain Elzarga totalling 83 ha. The Qattara Depression in the north-west of Libya lies under the sea level and is covered with temporary lakes, salt pans and salt marshes. Other large salt pans include Sabkhat al Hayshah close to the coast near the gulf of Sidra, and Sabkhat Shunayn and Ghuzayyil in the north-east.

Libya has a large number of natural springs in particular in the northern parts of the country, many of which are of good quality water. Some of the larger sources are Ayn Zayana, Ayn Kaam, Ayn Dabbousia and Ayn Tawargha (CEDARE, 2014).

Five major aquifers underlie Libya (Table 2). The first two aquifers are interconnected and form the Western Aquifer. Only the coastal aquifers, the Al Jefara in the north-west and the Al Jabal al Akhdar in the north east are shallow and naturally recharged from the rainfall, as well as part of the Al Hamada aquifer. Part of the Al Hamada, the Murzuq and the Al Sarir-Kufra aquifers, south of 29° North latitude, belong to the great sedimentary basins and are fossil water reserves where the water was stored during the Quaternary. The Al Sarir-Kufra aquifer is part of the Nubian Sandstone Aquifer System (NSAS), the largest aquifer in the world covering an area of about 2 million km² in Libya, Chad, Sudan and Egypt. The Al Hamada aquifer is part of the North Western Saharan Aquifer System (NWSAS) shared with Algeria and Tunisia and consisting of the shallow Terminal Complex sandstone and limestone aquifers and the deeper Continental Interlayer sandstone aquifer.

TABLE 2
Major aquifers in Libya (Abdudayem and Scott, 2014)

	Aquifers	Areas within Libya (km²)
1.	Al Hamada: Jabal Nafusah, Ghadamis and Al Hamada al Hamra sub-basins	215 000
2.	Al Jefara Plain	18 000
3.	Al Jabal al Akhdar	145 000
4.	Murzuq	350 000
5.	Al Sarir-Kufra	700 000

Before the 1960s, water from the shallow coastal aquifers could be extracted through wells and traditional tools thanks to shallow water table. From the 1960s onwards, however, pumps were necessary due to falling water table coinciding with the oil boom (CEDARE, 2014). During the oil exploration in the 1950s and 1960s, the deep fossil aquifers were discovered. Their water was first used on site, to develop agricultural projects in the desert close to the wells, but water scarcity and the intense population concentration in the north coast triggered the need to their transfer, initiating the Great Man-made River Project (GMRP) in 1984. Despite an estimated cost of over US$ 30 000 million, Libya relied only on national funding, especially from the oil sector. The final objective, after completion of the five phases, is to transfer 5-6 million m³/day to the northern cities through over 500 wells of 500 m deep and about 4 000 km of pipelines. Phase 1 finalized in 1991, being able to convey up to 2 million m³/day of water for 1 600 km to two reservoirs in the Benghazi and Sirte areas. Phase 2 brought up to 2.5 million m³/day along 1 227 km to Tripoli from 1997. Phase 3 enabled to transfer an additional 1.68 million m³/day of water from the Al Sarir aquifer to Tobruk through 621 km of pipeline. Phase 4 will extend the distribution network from Gadamis (Jabal Nafusah and Al Jefara aquifers) to the coast west of Tripoli, and phase 5 is intended to join both the eastern and western systems into a single network. However, the civil unrest stopped further works and some NATO bombings destroyed some reservoirs. Initially allocated to irrigation, transferred water from the GMRP is used at 98 percent by municipalities (EGA, 2013). Estimations of the availability of fossil water for this transfer vary greatly: between 50 years and over 4 000 years, depending on actual abstraction of water and sources.

Internal renewable surface water resources are estimated at 200 million m³/year and renewable groundwater resources at around 600 million m³/year, but 100 million m³/year is considered to overlap between surface water and groundwater, which gives a value of total internal renewable water resources (IRWR) of 700 million m³/year (Table 3). No surface water or groundwater is entering the country. The total renewable water resources are 700 million m³/year, or 111.5 m³/year per capita in 2015, Libya being thus well under the absolute water scarcity threshold of 500 m³/year per capita. Fossil groundwater water leaving the country to neighbouring countries is estimated at 700 million m³/year.

Currently 19 dams are in operation, including a secondary dam on Wadi Qattara, for a total storage capacity of about 390 million m³ (Table 3). However, their average annual storage capacity is only about 61 million m³ and in fact, due to lower flow records or damage to some dams, it is estimated to even not exceed 30 to 40 million m³/year. Some 20 dams are planned for construction representing an additional 136.6 million m³ of storage and 45 million m³ of additional average annual storage.

TABLE 3
Water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	56	mm/yr
	-	98 530	million m^3/yr
Internal renewable water resources (Long-term average)	-	700	million m^3/yr
Total renewable water resources	-	700	million m^3/yr
Dependency ratio	-	0	%
Total renewable water resources per inhabitant	2015	112	m^3/yr
Total dam capacity	2015	389.89	million m^3

Desalination started in Libya in the early 1960s and installed capacity reached 226.3 million m³/year in 2006 for a total of more than 400 desalination plants, including 17 large ones (GEC, 2006). In 2012, the total desalinated water produced in Libya is estimated at 70 million m³/year aimed at municipal and industrial water demands and using both thermal and membrane technologies. Thermal desalination plants are located directly at electricity generation facilities.

Libya also has 79 wastewater treatment plants in 2010 for a total capacity of 74 million m³, all of which were designed to produce effluents suitable for irrigation. However, out of the 504 million m³ municipal wastewater produced in 2012, only 40 million m³ were treated and directly used in irrigation on 2 900 ha.

INTERNATIONAL WATER ISSUES

Libya does not share any surface water with other neighbouring countries, but a most of its groundwater is shared (Table 4).

TABLE 4
Transboundary aquifers (Source: IGRAC, 2014; EGA, 2013)

Aquifer name	**Total aquifer area (km^2)**	**Sharing countries and respective share (%)**
Nubian Sandstone Aquifer System (NSAS)	2 607 9995	Chad (11), Egypt (38), Libya (34), Sudan (17)
Murzuq-Djado basin	450 000	Algeria, Libya, Niger
Northwest Sahara Aquifer System (NWSAS)	1 189 533	Algeria (68), Libya (24), Tunisia (8)

The Joint Authority for Study Development of the NSAS was established in 1992 with its headquarters in Tripoli, Libya, initially between Egypt and Libya, and then joined by Sudan in 1996 and Chad in 2000. It coordinates the activities of the countries related to the NSAS and enhance cooperation for its management, in particular through two agreements to exchange updated data.

The Sahara and Sahel Observatory (OSS) hosts a light structure for the management of the NWSAS since 2002. In 2008, a consulting mechanism was formulated to sustainably manage the groundwater resource. It includes a permanent Technical Committee composed of the respective national water authorities, alternatively presided over for one year by the three countries, operating since 2008.

WATER USE

In 2000, the total water withdrawal was estimated at 4 268 million m³, of which 83 percent was withdrawn for agricultural purposes, 14 percent for municipal purposes and 3 percent for industrial purposes. More than 30 percent of the municipal water demand was supplied by the Great Manmade River Project (GMRP). In 2012, the total water withdrawal is estimated at 5 830 million m³, including 4 850 million m³ or 83 percent for agriculture, 700 million m³ or 12 percent for municipalities and 280 million m³ or 5 percent for industries (Table 5 and Figure 2).

Groundwater (including fossil groundwater) provides over 95 percent of the water withdrawn or 5 500 million m³ in 2012 (Figure 3). The remaining is divided between surface water, with a total controlled volume of 170 million m³/year (CEDARE, 2014), desalinated water and wastewater. The National Strategy for Sustainable Development of 2008 considered that a "sustainable" groundwater abstraction should not exceed 3 650 million m³/year, despite only 650 million m³/year comes from renewable groundwater and 3 000 million m³/year actually comes from fossil water–from the Jefara plains (25 million m³), the Jabal al-Akhdar (25 million m³), the Kufra and Sarir (1 300 million m³), the Hamada (150 million m³) and the Murzuq (1 500 million m³). Due to the fact that fossil groundwater is not included in the renewable water resources, the current water withdrawal is more than 8 times the annual renewable water resources. More than half of the domestic water supplies in 2012 were from the Great Manmade River Project (MWR and CEDARE, 2012).

In rural areas people depend to a large extent on private water supply wells, rainwater reservoirs, and springs. A large number of industries, such as the chemical, petrochemical, steel, textile and power generation industries, depend on private sources for water supply, including desalination of seawater.

TABLE 5
Water use

Water withdrawal:			
Total water withdrawal	2012	5 830	million m³/year
- Irrigation	2012	4 850	million m³/year
- Municipalities	2012	700	million m³/year
- Industry	2012	280	million m³/year
• Per inhabitant	2012	947	m³/year
Surface water and groundwater withdrawal (primary and secondary)	2012	5 720	million m³/year
• As % of total renewable water resources	2012	817	%
Non-conventional sources of water:			
Produced municipal wastewater	2012	504	million m³/year
Treated municipal wastewater	2008	40	million m³/year
Direct use of treated municipal wastewater	2008	40	million m³/year
Direct use of agricultural drainage water		-	million m³/year
Desalinated water produced	2012	70	million m³/year

FIGURE 2
Water withdrawal by sector
Total 5 830 million m³ in 2012

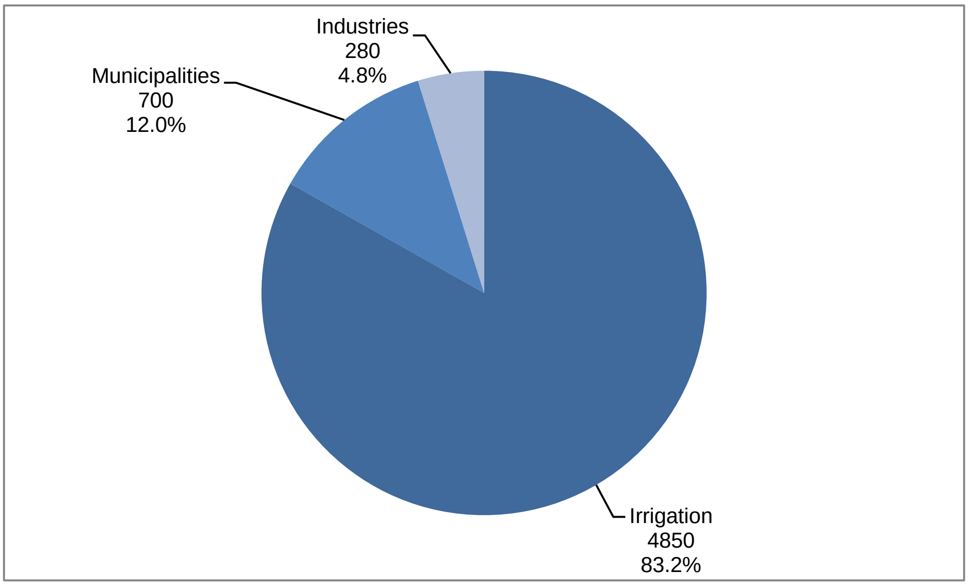
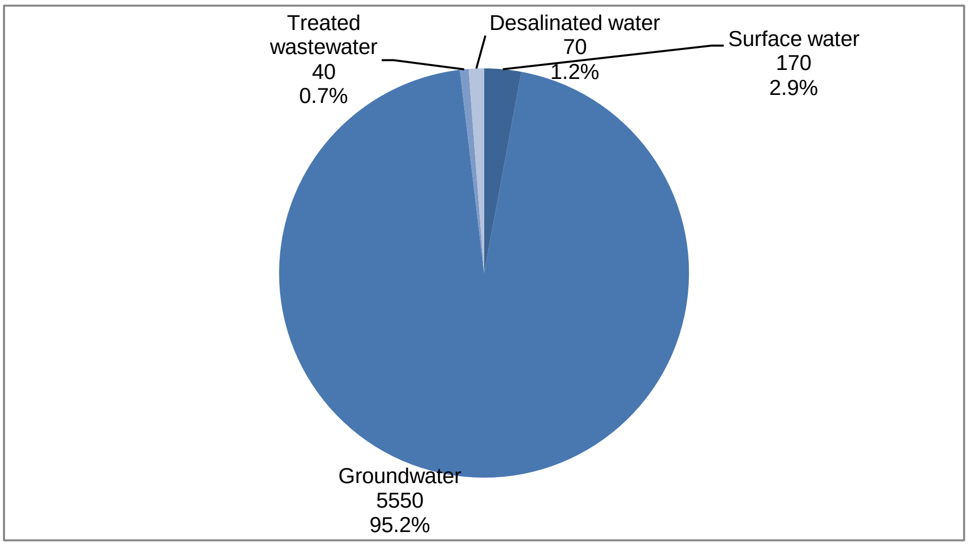


FIGURE 3
Water withdrawal by source
Total 5 830 million m³ in 2012



IRRIGATION AND DRAINAGE

Evolution of irrigation development

Irrigation potential has been estimated at 750 000 ha relying mostly on fossil water, but when considering renewable water resources, it decreases to 40 000 ha in the coastal areas (FAO, 1997).

Irrigation in Libya dates back to at least 500 years before the current era with the Garamantes, Saharan Berber people in the Fezzan area (Libya's southwestern region), who used an elaborate underground irrigation system to crop oases in the desert. Foggara, or underground channels directed water from aquifers to their farms through thousands of kilometres of tunnels. Regular vertical wells enabled maintenance of these channels. During the Roman era, Libya was the breadbasket of the empire using rain-derived run-off irrigation (Otman and Karlberg, 2007). In the 9th century, emirs of the Islamic Aghlabid dynasty repaired the Roman irrigation systems, bringing prosperity from agricultural surplus. In the early 20th century, Italians tried to develop agriculture during their colonisation of Libya, but even more massive amounts were spent on irrigated agriculture after its independence in 1947. As a result, more intensive irrigated farming developed rapidly from the 1960s onwards using shallow groundwater along the coast, but remained subsistence agriculture by the end of 1960s. Huge efforts and funds were deployed in the 1970s and 1980s to develop irrigation using local aquifer in the coastal areas (Otman and Karlberg, 2007). In particular, two research projects, the Kufra and Jefara wheat projects, used pressurized irrigation and water from the underlying aquifers but were abandoned in the late 1970s.

In 2000, the total area equipped for irrigation was approximately 470 000 ha, of which 316 000 ha was estimated to be actually irrigated, although this figure may be underestimated. Almost the entire area was equipped with sprinkler irrigation systems and used groundwater on 99 percent of the area, just a little treated wastewater and surface water was used on the remaining areas. With a total harvested irrigated area estimated at 406 000 ha in 2000, the cropping intensity was 129 percent.

There were three different categories of farming in the irrigation sub-sector:

- Private irrigation, generally on 1-5 ha plots, which receives substantial state support for water equipment, energy, and agricultural inputs. This type of farming is mostly concentrated in the traditional development areas, i.e. the Jifarah plain, the Jabal al Akhdar, and the Murzuq basin, and the actually irrigated area was about 257 000 ha in 2000, which was 81 percent of the total actually irrigated area in that year.

- Large-scale state farming, mainly located in the southern areas, where new irrigation schemes have been set up based on highly productive deep wells supplying water to blocks divided into small plots and cultivated by small-scale farmers.
- Large-scale state farming, mainly located in the desert areas (usually pivot systems), operated by state technicians and workers.

In 2008, although the total area equipped for irrigation decreased to 400 000 ha, the area actually irrigated increased to 335 000 ha (CEDARE, 2014). Decrease in the traditional irrigated areas on the coast results from (MWR and CEDARE, 2014):

- Limited water near the coast due to poor water quality and lowering of the water tables
- Neglect and deterioration of many large-scale government public irrigation schemes
- Encroachment of urban areas at the expense of the irrigated areas

On the other hand, new irrigation is being developed by the private sector using large pivots and drilling their own wells, up to 1 000 m deep (MWR and CEDARE, 2014). Apart from public supply wells associated with government production and settlement projects, all other wells are privately owned. In the so-called “settlement projects” each well serves a number of farms through an integrated irrigation network (CEDARE, 2014). The private farming sector is growing rapidly and is responsible for more than 80 percent of irrigated agriculture. Typical farms of 50 ha and more are to be found, well equipped with modern irrigation technologies and well adapted to the local market (FAO, 2009).

The Al Khadra irrigation development project, started in 2002 through a joint venture between American companies and the Libyan government with its the Great Manmade River Water Utilization Authority (GMRWUA), is an example of this expanding private irrigated farming. Initiated with 1 000 ha in the Benghazi area using mobile irrigation equipment, it expanded to 10 000 ha there, as well as 5 000 ha in the Sirte area, and 1 200 ha in Tarhona south of Tripoli. It grows a wide range of crops: cereals (wheat, barley, oat, maize), fodder (alfalfa and grass hay), fruits (grapes, peaches, pears and apricots), potatoes, and olives.

TABLE 6
Irrigation and drainage

Irrigation potential		40 000	ha
Irrigation:			
1. Full control irrigation: equipped area	2008	400 000	ha
- Surface irrigation		-	ha
- Sprinkler irrigation		-	ha
- Localized irrigation		-	ha
• Area equipped for full control irrigation actually irrigated	2008	335 000	ha
- As % of area equipped for full control irrigation	2008	84	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		-	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	**2008**	**400 000**	**ha**
• As % of cultivated area	2008	19	%
• % 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	2000-2008	-2	%
• 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		-	ha
Total water-managed area (1+2+3+4+5)	**2008**	**400 000**	**ha**
• As % of cultivated area	2008	19	%

TABLE 6 (Continued)
Irrigation and drainage

Size of full control irrigation schemes:	**Criteria**:			
Small schemes	< - ha		-	ha
Medium schemes	> - ha and < - ha		-	ha
large schemes	> - ha		-	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		2000	9 000	ha
• Non-irrigated cultivated area drained			-	ha
• Area equipped for irrigation drained			-	ha
- As % of total area equipped for irrigation		2000	1.9	%
Area salinized by irrigation		1998	190 000	ha
Area waterlogged by irrigation			-	ha

Role of irrigation in agricultural production, the economy and society

Yields from rainfed as well as irrigated agriculture are generally low. Apart from the aridity of the climate which reduces rainfed yields, this is due to prevailing shallow, coarse soils with limited natural fertility and high erosion risks. The average yield of irrigated wheat and barley is much lower than the yields obtained in other Mediterranean countries. The yields for irrigated fruits, vegetables and oil crops are generally also lower than in the surrounding countries but for these crops the differences are smaller. The main irrigated crops are cereals (wheat and barley), olives, fodder (mainly berseem cultivated in winter) and vegetables.

Given the arid nature of much of Libya, irrigated farming systems have always been of crucial importance in generating much of the country’s agricultural output. About 50 percent of the cereal production and about 90 percent of the fruit and vegetable production originate from irrigated agriculture.

Food security is felt as a moral imperative for the Libyan leaders and huge efforts were made in the 1970s and 1980s to develop irrigated agriculture based on local water resources, and in the 1990s to create the conditions for the rehabilitation and development of the coastal agriculture through water transport from the south to the north. However, food security is distinctly different from food self-sufficiency which is now impossible and will be more and more difficult to achieve in Libya. A debated question is whether irrigation, mostly the one based on costly water transfer, remains justified in a situation of water scarcity where the only source of water is non-renewable groundwater and where economic returns from other sectors (oil industry) would allow an easy access to the international food market.

Women and irrigation

In 2005-2007, about two thirds of the agricultural workforce were women (WFP, FAO, 2011). However, due to the lack of community involvement in irrigation and water management, there is no detailed information available about irrigators in general and about how many women may actually practice irrigation in particular. Workers on the large-scale private and state farming are traditionally in large part male migrants, but the situation might have evolved recently after the departure of many migrants since the 2011 events.

Status and evolution of drainage systems

In Libya, only about 9 000 ha is estimated to be equipped with some form of drainage in 2000. This is mainly due to the lack of experience in the country and the resulting high cost of drainage installation. Despite the fact that most of the area under irrigation uses sprinkler irrigation, the extent of the salinization issue, 190 000 ha in 1998 and probably higher with the increasing groundwater salinity level, would require more widespread drainage systems.

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

Institutions

The General Water Authority (GWA) was responsible for water resources management since its establishment in 1972. In 2012 a ministry was created, the Ministry of Water Resources (MWR), which combines all institutions dealing with water at national level, including the GWA:

- The GWA is responsible for the management of conventional water, both surface water and groundwater, but not desalinated water, wastewater or water from the GMRP. It is in charge of water resource assessment and monitoring, and supervision of irrigation and drainage projects within Libya. It comprises six General Directorates: Planning; Follow-up and Statistics; Water Resources; Dams, Irrigation and Drainage; Soils; and Finance and Administration. At regional level the GWA has five branches.
- The Great Manmade River Authority (GMRA), established in 1983, deals with the execution of the GMRP and management of its water.
- The Great Manmade River Water Utilization Authority (GMRWUA), established in 1994, oversees the use of water transported by the GMRP for agricultural purposes.
- The General Company for Water and Wastewater (GCWW) was established in 2008 for operation and maintenance of the water supply and sanitation systems. At regional level the GCWW has fifteen branches.
- The General Company for Water Desalination (GCWD), supplying desalinated water, was established in 2007 and was previously under the Ministry of Electricity. It oversees desalination plants that are not thermal, i.e. non-thermal and non-power desalination plants.

In addition, there are several other ministries:

- The Environment General Authority is a semi-autonomous organ, reporting directly to the office of the Prime Minister and setting the limits for contamination level in both drinking water and effluents. It also monitors water quality.
- The Ministry of Housing and Utilities implements water supply and sanitation plans, through its Housing and Infrastructures Board (HIB).
- The Ministry of Agriculture, Animal and Marine Wealth oversees agricultural activities and land use. According to its land use projections and corresponding water requirements, water shares for the sector are negotiated with the MWR.
- The Ministry of Energy and Electricity manages all power stations employing thermal desalination plants.

Water management

In the 1990s, a strategy for irrigation management transfer was proposed. However, it also highlighted that the complex water distribution system (through the GMRP) requires significant operation and maintenance skills that are lacking locally. The institutional structures of the Libyan society also required a complete change to allow for community-based institutions. However, this strategy was never implemented.

Finances

The water pricing strategy is based on the fact that water is a common good and that all citizens share it for different uses. As a result, tariffs differ according the uses and are subsidized by the state, in particular for the most vulnerable users. Despite the fact that water tariffs cover only a third of the total cost of water production, the recovery rate is low, also due to an irregular and not always existent billing system. Since independence the state also finances all infrastructure projects, both construction and operation and maintenance (MWR and CEDARE, 2014).

The 1994 resolution n.218 set the water pricing for the first phase of the GMRP with high subsidies for agriculture and municipalities: 0.048 Libyan dinar (LYD)/m^3 for agricultural use, 0.080 LYD/m^3 for urban use, and 0.796 LYD/m^3 for industrial use. The total cost of the GMRP water in 2011 is 0.235 LYD/m^3 (0.194 US$/$m^3$), including 0.089 LYD/$m^3$ (0.073 US$/$m^3$) for operational cost and 0.146 LYD/m^3 (0.12 US$/$m^3$) of capital cost (Abdudayem and Scott, 2014).

At present, farmers are only charged for the cost of energy used for water production and energy is also subsidized (CEDARE, 2014).

Policies and legislation

The first Water Law of Libya dates back to 1965 and aimed to regulate the exploitation of water resources. It declares water as a common good. It was superseded by the more comprehensive *1982 Water Law* (Law n.3), which designated water as a public property that should be protected by all. However, shallow and deep wells are considered private and their ownership is attached to the corresponding land. This *1982 Water Law* was further complemented then by laws, decrees and regulations in all domains, such as water ownership, usage, licensing for drilling, quality and management. In particular, decree n.790 in 1982 sets aquifer protection from overexploitation and pollution, and memo n.612 in 1993 regulates the water allocations from the GMRP. Practically, very little of this legislation has been implemented yet (FAO, 2009). Law n. 15 of 2003 on environmental protection and enhancement reinforces water quality protection and drinking standards.

The National Strategy for Integrated Water Resources Management (2000-2025) is the main guide on water management in Libya. It was formulated in 1999 and approved in May 2005 with the aim to stop water deficits and water quality deterioration in order to set a base for sustainable development. Operationalization is still to be formulated, but led to the National Program for Water Supply and Sanitation, aiming to provide access to safe water supply and sanitation to all Libyans through identification of all communities in need of reticulated systems, enhancement or upgrade of such systems. Finally, the National Strategy for Sustainable Development was formulated in 2008.

ENVIRONMENT AND HEALTH

Groundwater over-exploitation and use of fossil aquifers

Before the 1960s, large-diameter wells could easily extract shallow aquifers. Since the 1960s and the rapid development of oil production, groundwater extraction rate accelerated to such level that pumps became necessary to cope with the falling water tables (CEDARE, 2014). The coastal aquifers, Jefara plains and the Jabal al Akhdar aquifers, are now seriously overexploited and this is the main reason for the exploitation of the much deeper and non-renewable aquifers in the south of the country (FAO, 2009).

Water quality

Deterioration of the water quality due to untreated municipal wastewater exists, however the main concern regarding water quality is related to saline intrusion in the coastal aquifers, where both population and agricultural activities are concentrated. The uncontrolled mining of groundwater for agriculture and falling water tables of the coastal aquifers, result in seawater intrusion, with an interface progressing up to two kilometres inlands in the Jefara plains and salinity levels increasing from 150 ppm to over 5000 ppm during the period 1950-1990.

Salinization

Irrigation with increasing saline groundwater has led to soil salinization in some locations. For example in the Jefara plains, two irrigation schemes built in the 1970s with artesian wells, have now converted to pumped wells and have some waterlogged and salinized soils (CEDARE, 2014). Salinization increases irrigation water demands while crop yields decrease. Other examples exist in the southwestern part of Libya, as well as in the Murzuq basin due to inadequate drainage.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

In the short term, low water and energy costs are still likely to encourage development of private irrigation from private wells in the southern parts of the Libya.

In 2025, the water demand is estimated between 8 200 and 12 500 million m^3 depending on the sources (Tinmore Institute, 2012; Lagwali, 2008). To fulfil these demands, phases 4 and 5 of the Great Manmade River Project (GMRP) are still to be implemented. However, considering the population growth, the amount of water transferred from the south to the coastal areas will certainly be used almost entirely for domestic use, despite the fact that the GMRP was originally intended for irrigated agriculture.

Any increase in irrigated agriculture will have to come from an increase of production and use of non-conventional water, either:

- directly in agriculture with increase in the collection and treatment of wastewater and its use in agriculture; or
- in other sectors that might free some transferred water from the GMRP for agriculture. For example, increased desalinated water for both municipalities and industries.

Some desalination plants are planned or already under construction for an anticipated production capacity of 86.5 million m^3/year in 2025 (CEDARE, 2014).

Finally, in response to water scarcity, the Libyan government also made strategic agricultural investments outside the country in areas where water for irrigation is still available. The largest of these investments is the Malibya fund in Mali which obtained a 50-year renewable lease for 100 000 ha in the Office du Niger in exchange of the construction of an irrigation canal. The land comes with unlimited access to water for a small user fee. By 2009, a 40-km irrigation canal, using the same water irrigating the rice fields of small farmers in the Office du Niger, was completed. The project was suspended after the 2011 Libyan crisis, but in 2012 the new government confirm that it will maintain their investments in Mali (GRAIN, 2016).

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