Defining a new approach to water management in LIBYA | issues & options

AFRICAN DEVELOPMENT BANK GROUP
GROUPE DE LA BANQUE AFRICAINE DE DÉVELOPPEMENT

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LIST OF ACRONYMS

EC	Executive Council
EGA	Environmental General Authority
GCWW	General Company for Water and Wastewater
GDC	General Desalination Company
GECOL	General Electricity Company of Libya
GIS	Geographic Information System
GWA	General Water Authority
GWRA	General Water Resources Authority
IBWT	Inter Basin Water Transfer
JA-NSAS	Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System
MHU	Ministry of Housing and Utilities
MmRA	Man-made River Authority
MmRP	Man-made River Project
MWR	Ministry of Water Resources
NMC	National Meteorological Centre
NRW	Non-revenue Water
NSAS	Nubian Sandstone Aquifer System
NSIWRM	National Strategy for Integrated Water Resources Management 2000-2025
NWSAS	North Western Sahara Aquifer System
OECD	Organisation for Economic Co-operation and Development
OSS	Sahara and Sahel Observatory
PPP	Public-Private Partnerships
UFW	Unaccounted-for Water
UNSMIL	United Nations Support Mission in Libya
WW	Wastewater

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EXECUTIVE SUMMARY

Libya has deployed enormous investments in the water sector to mobilize water resources to meet the country's growing water demand for domestic, agricultural, and industrial sectors. Numerous water supply projects have been implemented, as well as water resources mobilized from unconventional water sources. These comprised of groundwater abstraction infrastructure, seawater desalination plants, small dams and a huge groundwater transfer project from the south to the north, the Man-made River Project (MmRP), which total cost until the end of 2017 was reported by Project Authority to be 12.4 Billion Libyan Dinars (about $ 8.9 billion[1]).

Libya relies essentially on its non-renewable groundwater resources to meet its water needs, as surface water resources are scarce, and renewable groundwater resources are extremely limited. Except for the main Mediterranean coastal strip, the country is characterized by arid and desert climate conditions, where rainfall is very scarce.

National water demand is currently estimated at 4,309 million cubic meters per year (Mm^3/year) compared to 820 Mm^3/year of available renewable water. This leaves an enormous gap of nearly 3,489 Mm^3/year between renewable water supply and water demand, amounting to over 5 times the shortfall in the volume of renewable water available to meet annual water demand. Based on the projections, the total water demand by the year 2025 may fall between 4,528 and 4,995 Mm^3/year for assumed growth rates of 1 and 3% respectively. Growth rates are highly dependent on peace and stability and, to a lesser extent, on oil production. The agricultural sector in Libya accounts for most of the water withdrawal (79%), while domestic and industrial uses account for the remaining 17% and 4% respectively.

Within this frame of pressure on renewable water, the country turned to non-renewable groundwater to cover the existing gap. The MmRP project consists of transferring groundwater, over a distance of more than 4,000 km, from the large sedimentary basins, between 400 and 800 meters deep in the Nubian sandstone aquifer system in the southeast and the Cambro-Ordovician aquifer system of the Murzuq basin in the southwest, to the coastal region in the north, where most of the population and the economic activities are concentrated. The MmRP in its final phase is expected to deliver about 6.5 Mm^3/day, of which 75 to 80% were originally allocated to agriculture. This ratio is gradually shifting in favour of domestic use. Pre-2011 levels of mobilization were above 2 Mm3/day. At present, the MmRP secures about 60% of the domestic water supply.

The water resources policy in Libya is partly driven by agricultural needs with focus on basic food self-sufficiency. Prior to 2011 conflict, about 10% of cereals and 62% of fruit and vegetable needs were met from local agricultural production. However, the 2011 conflict has worsened the agriculture production's situation, and Libya remains reliant on imports to satisfy its basic food requirement. The sector still has the potential to expand and increase its efficiency as food security will remain a top priority, specifically should Libya wish to pursue self-sufficiency in basic foods. Given that water consumption for irrigation accounts for about 80% of the total used groundwater resources, the issue of managing water resources in Libya is highly dependent on the irrigated agriculture policy. The 2000-2025 Water Strategy has set priorities for water use and called for adopting virtual water[2] as a principle for defining type of locally produced items. However, no national policy on food production options is yet implemented. For example, a trade-off between enhancing agriculture production to secure basic food self-sufficiency, or adopting an option based on an optimum internal food

1- Figures are in USD, considering 1 USD equivalent to 1.39957 LYD

2- The virtual water is defined as the water embedded in a product, that is, the water consumed during its process of production (Food Safety and Human Health, 2019) production and food import. Such a policy would have a significant influence on water resources management in the country. Indeed, considering physical and economic constraints of the renewable water resources, future food production is expected to rely exclusively on non-renewable and non-conventional water. Therefore, the extent to which these resources can be further developed must be studied, as the MmRP with its 6.5 Mm^3/day limit in the final phase, may not be able to fill the gap.

The current National Water Policy does not give enough consideration to the water demand management and the Government of Libya subsidizes water and energy, which has not promoted efficiency of water usage. Rather, the focus of the Libyan public authorities is on increasing water supply through the development of conventional and non-conventional water resources, mainly groundwater transfer and seawater desalination. With the water offer reaching its ceiling, the country has no other alternative but to adopt a new water strategy based on water demand management. It will cope with the increasing gap between the water supply and the water demand, which gets wider as a result of the country's demographic and economic growth.

Solutions exist and their implementation within the framework of an innovative and integrated approach for the whole water sector should allow the country to solve the most urgent problems and make water a decisive factor for its sustainable development.

The new water management approach should put water demand management on top priority, as its potential for global water saving is very high. Pre-conflict water losses accounted for nearly 40% of the total water demand, and a substantial part of these losses, estimated at 1,200 Mm^3/year, could be recovered in the long-term through improvement in domestic water and irrigation distribution systems.

In the irrigation sector alone, a potential of 1,000 to 1,100 Mm^3/year could be recovered by the year 2040. Agricultural water demand is somewhat distorted by low irrigation efficiency, as water use for certain crops, mainly wheat and barley, is reported to be much higher than the standards in other countries with similar climatic conditions. Thus, increasing water usage efficiency and enhancing the productivity of water used in irrigation through improved seeds varieties or diversification into higher value crops, for example are critical.

Prior to 2011, the functionality and availability of water services were relatively adequate, although sub-optimal in quality, thanks to the large investments made in the construction, operation, and maintenance of water sector infrastructure. However, the situation has drastically changed since 2011. Like all other aspects, civil unrest caused severe damage to the water sector. Currently, functionality and water services availability face critical challenges caused by aging facilities, incessant armed conflict, political, economic, and institutional instability, as well as continuous cuts in the power and fuel supply, in addition to the human resources capacities in the water sector, which have been decimated by staffdisplacement, administrative split, and the lack of investment in the sector. Therefore, the country not only faces production challenges but also significant access, distribution, and service problems.

A comprehensive analysis was conducted on the impact of the water policies adopted so far in Libya, as well as on the identification of achievements and gaps in the sector. The major technical, institutional, and regulatory constraints and challenges of the water sector have been identified and analysed. These include:

- Growing gap between water supply and water demand;
- High water losses in the municipal water and irrigation distribution systems mainly due to poor infrastructure, malpractice and inefficient water usage;
- Groundwater depletion in coastal aquifers, and threats of accelerated seawater intrusion;
- Degradation of water supply, sanitation and irrigation infrastructure;
- Disruption of operation and maintenance services of water supply and sanitation infrastructure;

- Insufficient funding provided to the water sector, associated with inadequate water pricing and weak water cost recovery;
- Insufficient monitoring and evaluation;
- Limited data in the existing water information system;
- Weak institutional and regulatory frameworks and capacities;
- Lack of long-term water sector planning;
- Incertitude caused by extreme events as climate change related droughts and increased temperatures.

This report reflects on the strategic areas of results for a new Water Management Approach for Libya, which guarantees the equitable and sustainable use and management of water resources for socio-economic development, regional cooperation, and environmental protection. Its development is based on the analysis of numerous studies and technical reports on the water sector in Libya. Going further, these areas of results have been factorized into a set of goals that may provide appropiate solutions to bridge the water sector gaps in the medium and long term. Seven programming principles are mainstreamed along with all the strategic processes. The eight areas of results identified for the medium and long-term are:

1. Reduction of the gap between water supply and water demand by focusing on water demand management, concentrating on the reduction of non-revenue water[3], the implementation of water saving technologies especially in the agriculture sector, and the setting of a cost recovery tariff.
2. Change in the water supply approach, with the major change about switching from non-renewable groundwater withdrawals to the scale-up of non-conventional resources, such as desalination or wastewater recycling;
3. Prioritizing the universal access to water and sanitation services; as this was the case prior to 2011, when water supply and sanitation services were relatively higher at about 65%;
4. Enabling the environment for private sector participation, which will enhance the achievement of the ambitious challenges the country is confronting;
5. Protection of water resources, through the development of an integrated water resources management approach and the implementation of active measures for the conservation and restoration of water bodies;
6. Skills development and data management, which is a very relevant area for water resources management and for enhancing private sector participation, amongst others.
7. Strengthened water governance, which will include the strengthening of the regulatory and institutional framework, and set the basis for a performance-based culture for the water and sanitation services;
8. Development of a climate change adaptation strategy. Climate change, coupled with rising water demand, will put additional pressure on Libya’s scarce water resources. Therefore, sound water management practices must be applied alongside the development of non-conventional water resources and the reorientation of irrigation water policies.

3- Non-revenue water (NRW) is water that has been produced and is “lost” before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies).

INTRODUCTION

Total renewable water resources in Libya amounts to 820 Mm³/year, or 126 m³/year per capita (2020), well under the absolute water scarcity threshold of 500 m³/capita identified as water stress level by the United Nations. With a water demand of 4,309 Mm³/year, Libya relies essentially on its non-renewable groundwater resources to meet its water needs, as surface water resources are scarce, and renewable groundwater resources are very limited.

Libya has deployed enormous investments in the water sector to mobilize water resources to meet the country's growing water demand for domestic, agricultural and industrial sectors. Several water supply projects from conventional and unconventional water resources have been successfully implemented. They comprise groundwater abstraction infrastructure, seawater desalination plants, small dam reservoirs and a huge groundwater transfer project from south to north: The Man-made River Project (MmRP).

Population-to-water Scarcity Thresholds

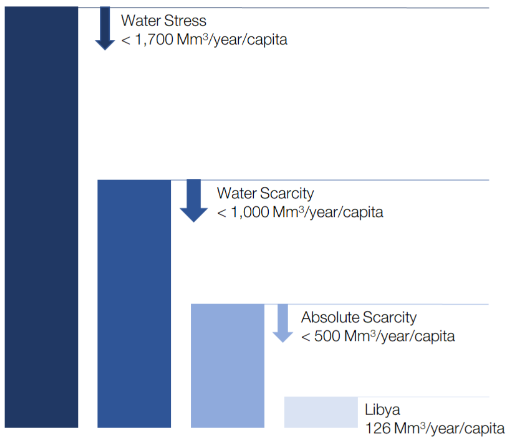


Figure 1 - Source: www.un.org

Demographic and economic growth have traditionally put increasing pressure on the available water resources. Moreover, after 2011 and until now, the situation in Libya has resulted in serious damage affecting the functionality and water services availability, aggravated by political, economic and institutional instability, along with the continuous cuts in the power and fuel supply. As a result, the country has significant access, distribution, and usage problems, not just a production problem.

The present report aims to lead the reflection about a new water management approach for the medium and long-term sector development in Libya. It is based on reviewing numerous studies and technical reports on the water sector. The analysis of these documents made it possible to understand the water sector issues, identifying the achievements and gaps of the sector, as well as the major constraints (technical, institutional, and regulatory) impeding management of the water sector. The review and analysis of the water sector included the following:

- Assessment of water resources availability, including potential non-conventional water resources;
- Analysis of future trends of the global water supply-demand balance;
- Evaluation of past water resources development investment programs and their relevance to meet different sectoral water demand;
- Current conditions of the existing hydraulic infrastructure and the problems posed by its operation and maintenance;
- Analysis of the water resources allocation policy to the sub-sectors of drinking water supply, sanitation, industry and irrigation;
- Water utilization performance, both in terms of the overall management and the efficiency of water use systems;
- Analysis of the environmental problems impeding the management of water resources, particularly the problems related to water and soil salinity, and the threats of seawater intrusion into coastal aquifers;
- Analysis of the impacts of previous drought periods on the availability and management of water resources and the performance of water management, and allocation procedures implemented during periods of climatic stress.
- Analysis of the water pricing policy being practiced in the various water sub-sectors, and their impact on water development and management;
- Analysis of the degree of involvement of private sector in the water sector;
- Analysis of the water sector capacity building, including an evaluation of the existing 'Water Information System'.

A comprehensive analysis was conducted on the state of the art of the water sector in Libya, and major obstacles, current or potential, have been identified and analysed for consideration while developing a new water management approach.

The analysis identifies eight areas of results, proposing specific targets within the 2040 horizon. It has been designed relying on seven programming principles, which are transversally developed all along the analysis. The proposed approach aims at guaranteeing water security[4] for current and future generations. It promotes inclusive socio-economic development for Libya, mediating between water demand and supply and the environmental needs to ensure sustainable development of the country's water resources while providing affordable high-quality services.

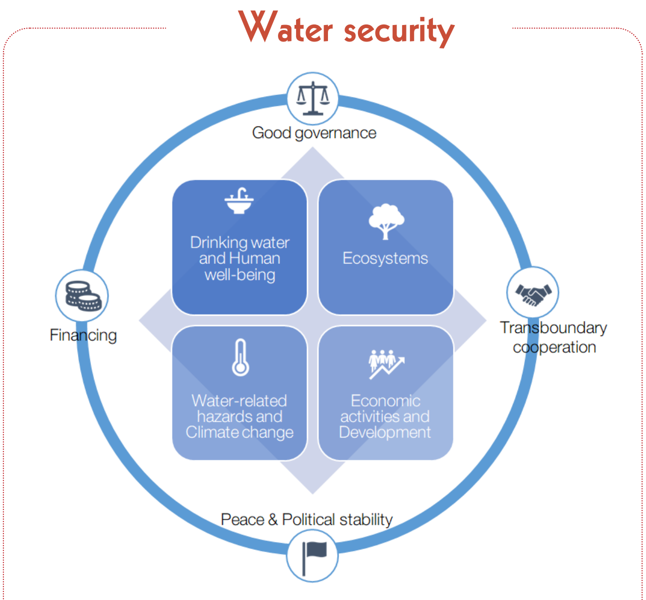


Figure 2 - Source : www.un.org

Findings of the water sector analysis, along the water sector goals, and the proposed areas of results for the new water management approach will be the object of the sector dialogue with Libyan relevant authorities. This may lead to an update and improvement of the water sector framework in Libya, including the institutional, regulatory, and strategic frameworks.

4- Water Security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2013)

I.

OVERVIEW OF THE CLIMATIC CONDITIONS

General map of Libya

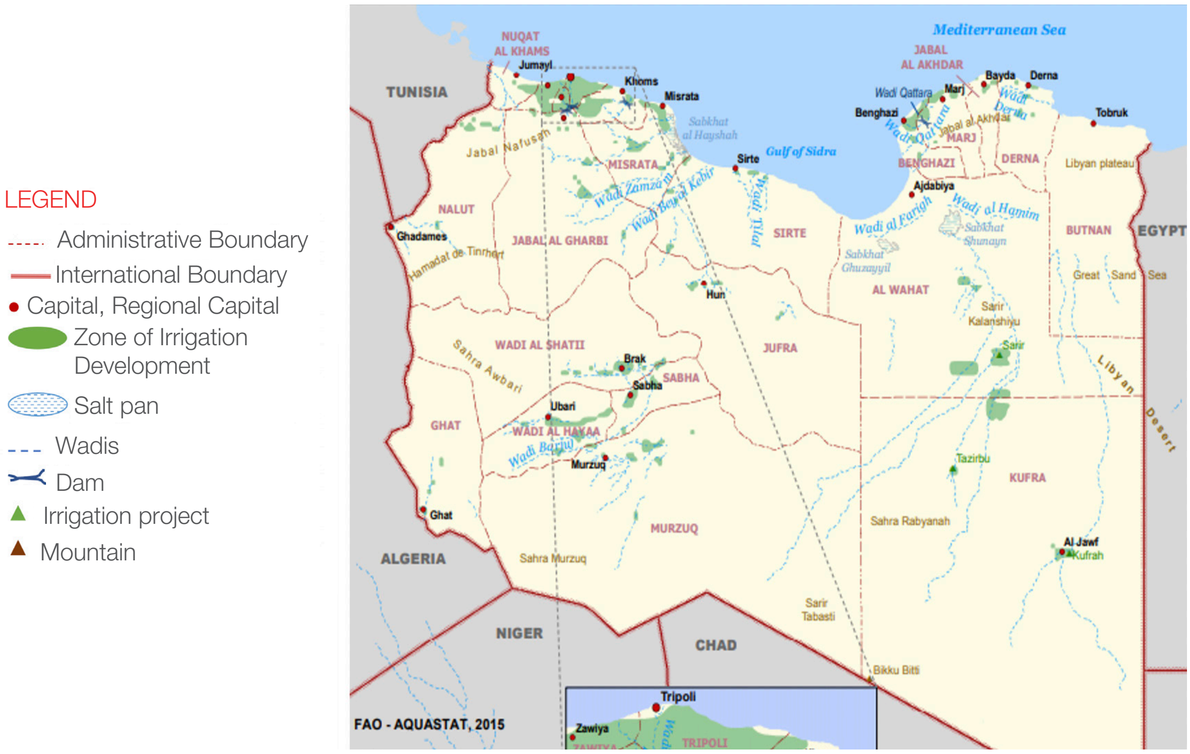


Figure 3 - Source: Aquastat, 2015

The climatic conditions in Libya are influenced by the Mediterranean Sea to the north and the Sahara Desert to the south, resulting in an abrupt climate transition. The following broad climatic divisions are defined:

Distribution of annual rainfall

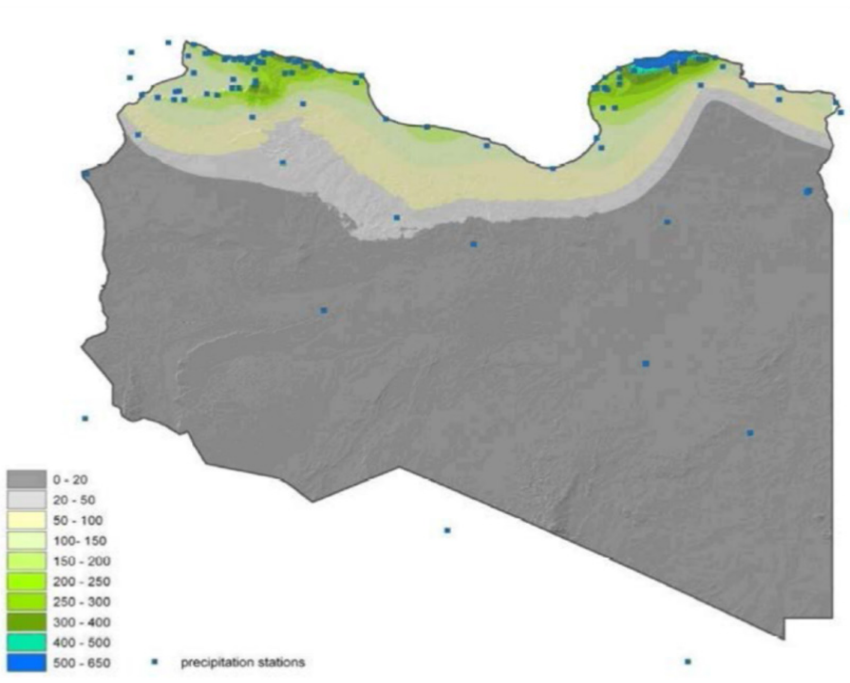


Figure 4 - Source: Hamad, Salah (2012)

- The Mediterranean coastal strip has dry summers and relatively wet winters;
- The Jabal al Akhdar to the east and Jabal Nafusah highlands are characterized by higher rainfall and humidity and low winter temperatures;
- Moving southwards to the interior, pre-desert and desert climatic conditions prevail, with torrid temperatures and large daily thermal variations; rain is extremely rare and irregular.

Annual rainfall is extremely low, about 93% of the territory receives less than 100 mm/year. The highest rainfall occurs in the northern Tripoli region (Jabal Nafusah and Gefara plain) and in the northern Benghazi region (Jabal al Akhdar), these two areas are the only ones where the average annual rainfall exceeds 250-300 mm (Pallas & Salem, 2001).

Projected climate changes include an increment in the mean annual temperature by 2°C by 2050, resulting in more frequent heat waves and fewer frost days. The frequency of droughts, dust storms, sandstorms, and flood will increase, along with increased desertification. By 2050, annual precipitation is expected to decrease by 7% below the current annual precipitation by 2050, with an increase in intensity of rainfall events.

II.

OVERVIEW OF WATER RESOURCES

Libya relies partly on non-renewable transboundary groundwater resources. The main groundwater resources are part of two major transboundary aquifer systems: the Nubian Sandstone Aquifer System (NSAS) and the North Western Sahara Aquifer System (NWSAS).

Groundwater resources in Libya consist of five large aquifer systems (basins)[5] (Figure 5). The coastal basins, Gefara in the northwest and Al Jabal al Akhdar in the northeast, as well as part of the Hamada basin, receive direct recharge from precipitation. The Kufra-Sarir and Hamada are part of two major transboundary aquifer systems: the Nubian Sandstone Aquifer System (NSAS) and the North Western Sahara Aquifer System (NWSAS). These aquifer systems are mostly non-renewable and contribute substantially to the country's water supply.

Renewable groundwater resources[6] are located in the basins of the Gefara plain, Jabal Akhdar and parts of the Hamada basin. The total amount of renewable groundwater is estimated at 650 Mm^3/year. Non-renewable groundwater resources[7] are found in large sedimentary basins in the Kufra-Sarir in the south-east, and the Murzuq-Hamada in the south-west[8].

Groundwater basins in Libya

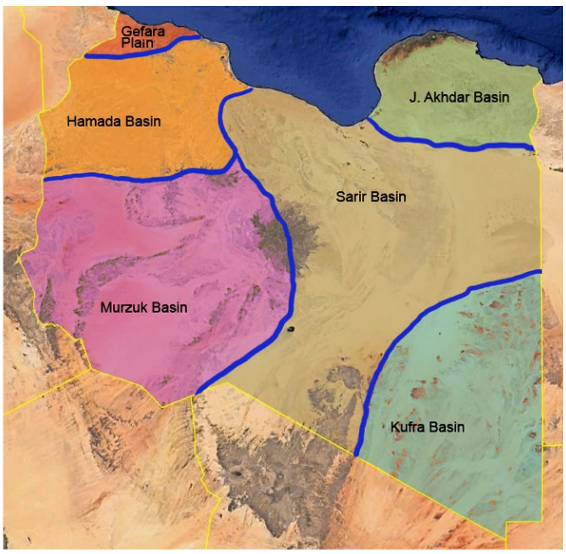


Figure 5 - Source: Salem (2005), Own elaboration

Extension of the Nubian Sandstone Aquifer System (NSAS)

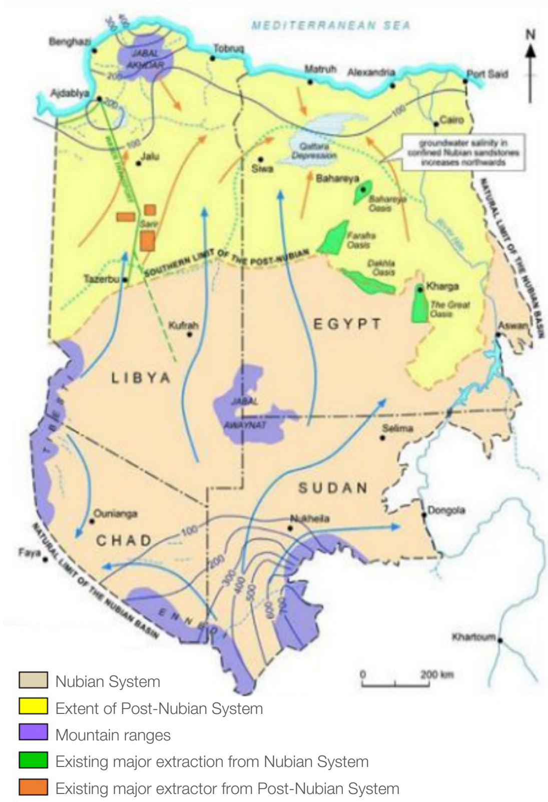
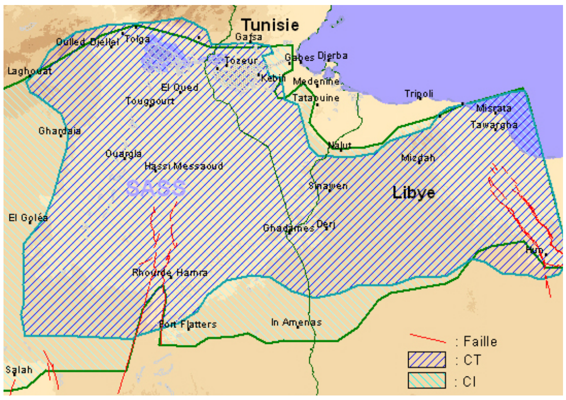


Figure 6 - Source: CEDARE, 2001

Extension of the North-Western Sahara Aquifer System (NWSAS)



Complex Terminal (CT)
Continental Intercalare (CI)

Figure 7 - Source: OSS, 2002

5- Kufra and Sarir are two basins that are interconnected and form one regional groundwater system and are therefore referred to as Kufra-Sarir basin. The main aquifers of the Kufra basin are Paleozoic and Mesozoic in age, while the Sarir basin which lies north of the Kufra basin, consists of Post Eocene aquifers.
6- Renewable groundwater resources are the total amount of a country's groundwater resources, which are generated through the hydrological cycle.
7- Non-renewable groundwater resources are groundwater bodies (deep aquifers) that have a negligible rate of recharge on the human time-scale and thus can be considered non-renewable.
8- It is worth noting that most of the Hamada basin receives annual recharge.

The Nubian Sandstone Aquifer System covers an area of more than two million km² in North-East Africa, of which 235,000 km² (11%) in Chad, 828,000 km² (38%) in Egypt, 760,000 km² (34%) in Libya, and 376,000 km² (17%) in Sudan (figure 6).

The North-Western Sahara Aquifer System covers a total area of more than one million km²: 700,000 km² in Algeria (68%), 80,000 km² in Tunisia (8%) and 250,000 km² in Libya (24%). This aquifer system is essentially composed of sedimentary deposits, as shown in figure 7.

Surface Water Resources

There are no perennial rivers in Libya, but only intermittent streams or seasonal 'wadis' that flow only during the rainy periods. Surface water resources are limited and contribute less than 4% of the overall water resources. Total runoff is estimated at 200 Mm³/year, originating mainly in Jabal Nafusah and Jabal al-Akhdar highlands. Heavy rains, though exceedingly rare, can cause major floods during the winter period from October to February. They play a major role in recharging the coastal aquifers in northern Libya, and in sustaining the flow of several springs (Salem, 1997).

Unconventional Water Resources: Seawater desalination

Desalination is the main unconventional water resource used in Libya. Due to water shortages in the past, Libya turned to desalination as a supplementary water resource. The use of desalination was necessary to close the domestic water supply-demand gap. Thermal and membrane desalination technologies are the most used in the country. The total amount of water produced by desalination in 2012 was about 70 Mm³/year; production fell over in recent years due to thepolitical instability and armed conflicts, which affected the chemicals stock and the operation of plants.

UNCONVENTIONAL WATER RESOURCES: REUSE OF TREATED WASTEWATER

Treated effluents are an important unconventional water potential resource. Libya has built nearly 73 sewage treatment plants that have been designed to produce treated municipal effluents suitable for irrigation. Although the design capacities of these wastewater treatment plants exceed 220 Mm³/year, the quantities of treated effluents were only 46 Mm³ in 2012 and the quantity reused for irrigation was still quite low, amounting to just 15 Mm³/year for the same year. The treated wastewater dropped to 27 Mm³/year in 2019 and to only 16 Mm³/year in 2020 with no reuse for agriculture.

Desalination Ouptut (Mm³/year)

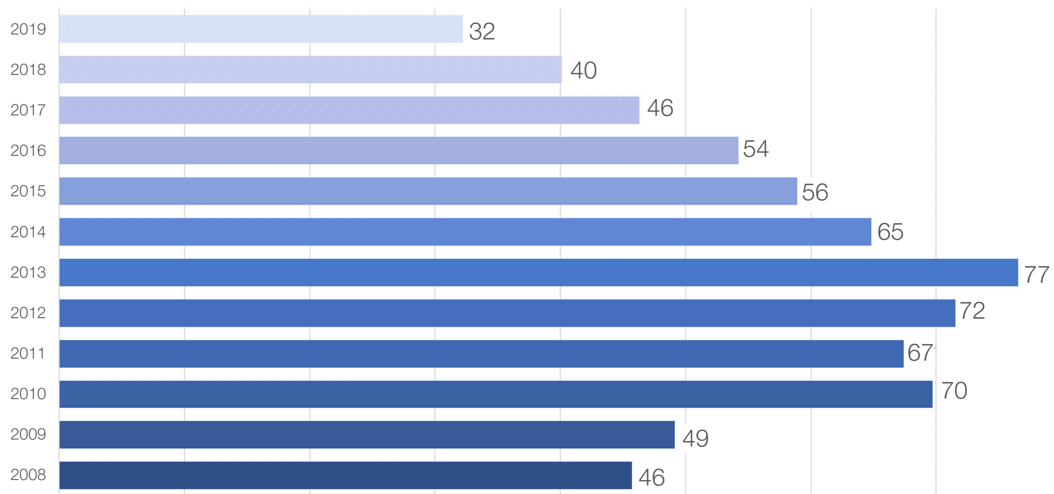


Figure 8 – Source: GDC

Desalination Ouptut (Mm³/year)

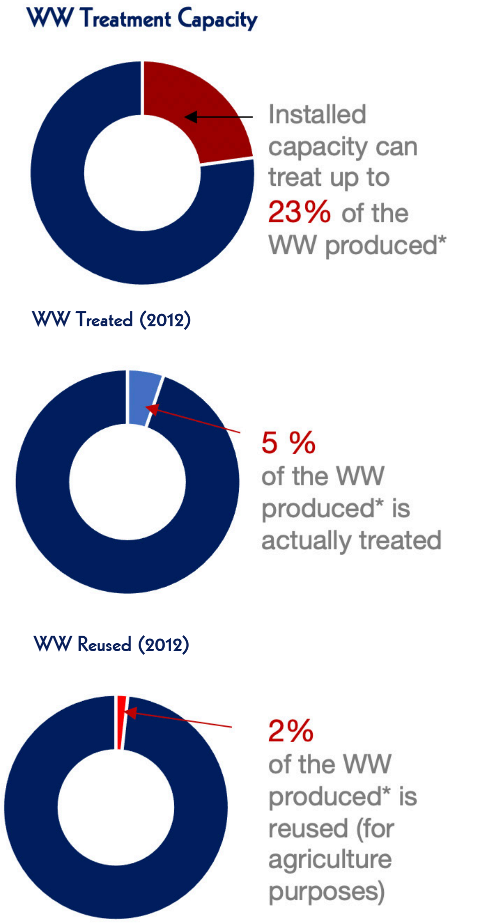


Figure 9 - Source: African Development Bank Group

* Wastewater produced by municipal and industrial uses

CLIMATE CHANGE EFFECTS ON WATER RESOURCES

The anticipated increase in annual drought days on the coast within the next forty years is expected to put significant stress on all water resources. The groundwater resources in the large sedimentary basins won't be affected by the rain pattern's change, as they are not significantly recharged by local precipitation. However, the aquifers extend over multiple borders, the most notable being the Nubian Aquifer extending into Egypt, Chad and Sudan. All these countries face their own water security issues, and the excessive withdrawal from local aquifers by any of the four countries will have a negative impact on the rest of the basin.

Water Resources Allocation

IRRIGATION

The Manmade River Project is intended to provide irrigation water to several agricultural projects and private farms in the affected zones in the north. Additionally, local groundwater abstractions by farmers provide water for irrigation along the coastal region. Allocation of water to the agricultural sector accounts for about 79% of the total mobilized water resources and represents a volume of about 3,422 Mm³ per year in 2020. The current irrigated perimeters are about 372,000 hectares, over 70% of which are located in the Gefara plain and the coastal strip between Khoms and Misrata in the northwest and in the Benghazi plain and the Jabal Al Akhdar in the northeast.

Irrigation areas in Libya

Figure 10 - Source: Google Earth

MUNICIPAL WATER SUPPLY

Municipal and rural water supply is estimated at 715 Mm³/year in 2020, representing about 17% of the total mobilized water resources.

Municipal water supply in Libya is provided mainly by:

- The MmRP project;
- Seawater desalination units managed by the General Desalination Company (GDC), and;

- Groundwater wellfields managed by the General Company of Water and Wastewater (GCWW).

The information available from the GCWW on this sector shows that in 2015 the MmRP provided more than 62.2% of municipal water needs in the east and west of the country (374 Mm3/year), while 7.8% (47 Mm3/year), was provided by seawater desalination units located in coastal areas. GCWW provided the remaining 30.0% (180 Mm^3) from a local network of wells. Water supply in rural areas is secured to a large extent by private wells, rainwater reservoirs, and springs.

Sources of domestic water supply (%)

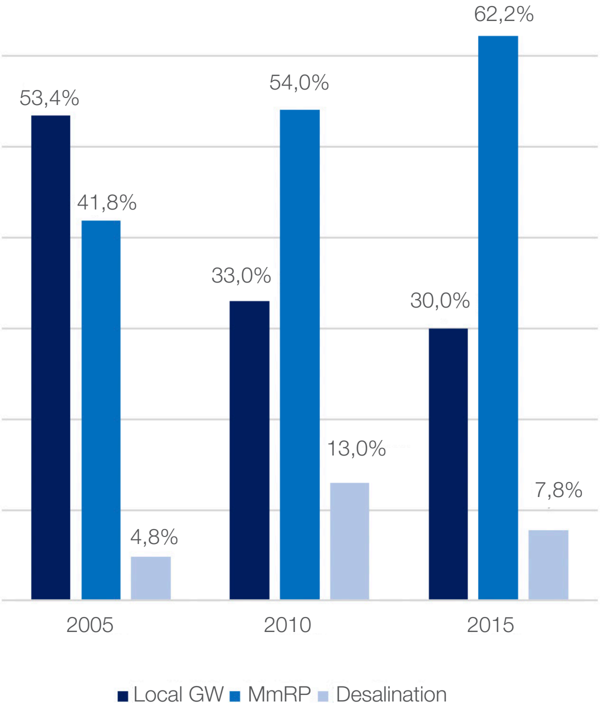


Figure 11 - Source: GDC, GCWW

INDUSTRIAL USE

Allocation of water to the industrial sector represents only about 4% of the total mobilized water resources, estimated at 172 Mm^3 in 2020. Many industrial units have their own water supply facilities, including wells for groundwater abstractions and seawater desalination, as is the case for chemical, petrochemical, steel, textile and of energy production.

Water allocation by sector (%)

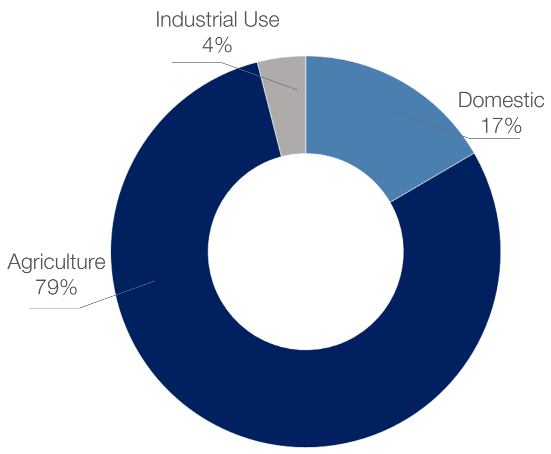


Figure 12 - Source: African Development Bank Group

Water Production

Water supply by source (%)

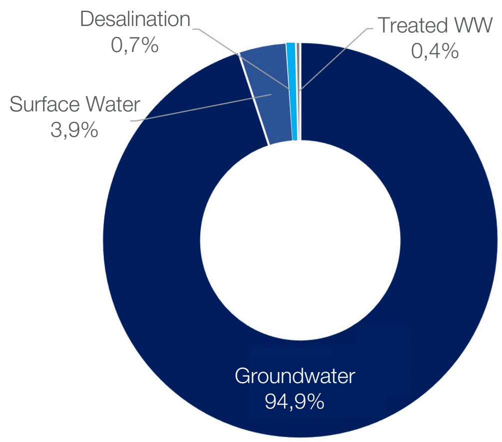


Figure 13 - Source: African Development Bank Group

To satisfy the water demand, the country relies to a large extent on groundwater resources, that represent 95% of the total estimated water produced in 2020. Non-renewable water accounts for 3,441 Mm^3/year, about 80% of total water use.

Breakdown of water production 2020 (Mm³)

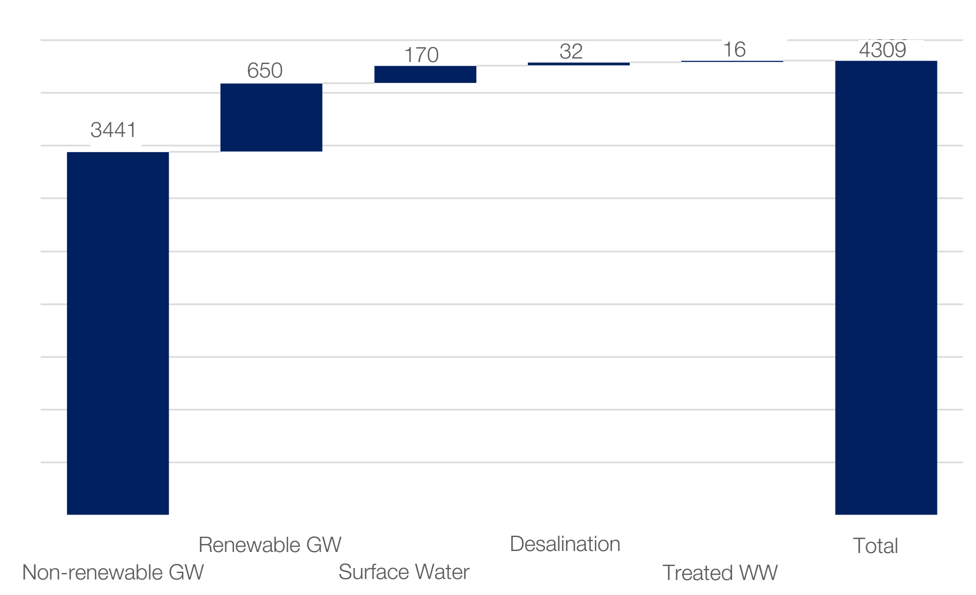


Figure 14 - Source: African Development Bank Group

Water Balance

Water balance is the difference between supply and demand and could either be positive or negative, depending on whether the supply exceeds demand or the other way around. This relationship changes over time as demand is a function of several factors including population growth, economic conditions, urbanization, and water use policies. On the other hand, quantities of water supply that are readily available for use, can also vary over time. This is a result of changes in the state of knowledge on water resources, losses of potentially available water bodies due to water quality deterioration and pollution, changes resulting from climate change such as prolonged periods of drought, and changes related to the contribution of non-conventional resources such as desalination and wastewater treatment. Unconventional resources are usually excluded due to their unstable condition and minor contribution.

Several attempts have been made in the past to calculate the overall water balance at national level or for specific regions or basins. A basin-wide water balance is indeed more realistic as it reflects the size of the locally encountered deficits or surpluses that are often hidden at a broader scale. While demand can either be measured or estimated to a certain degree of accuracy, supply is rather difficult to quantify especially under arid and semi-arid conditions where huge water reserves resulting from paleo-recharge during the Holocene and Pleistocene under paleo-climatic conditions are stored in large sedimentary basins and often referred to as fossil groundwater.

The Tripoli Statement issued by the participants of the International Conference on Regional Aquifer Systems in Arid Zones – Managing Non-Renewable Resources, held in Tripoli in November 1999, introduced a new concept of planned groundwater mining. It states that "in many arid countries, mining of non-renewable groundwater resources could provide an opportunity and a challenge, and allow water supply sustainability within foreseeable time-frames that can be progressively modified as water related technology advances" and recommended that "groundwater mining time-frames should account for both quantity and quality with criteria set for use priorities, and maximum use efficiency, particularly in agriculture".

The principle of planned groundwater mining forms the basis for all groundwater development projects in Libya, including the MmRP. Groundwater models were successfully applied to determine the size and the time scale for exploitation within pre-defined criteria that limit harmful effects on existing settlements and ecosystems.

In order to make a reasonable evaluation of a long-term water balance in Libya, the national water authorities deemed it necessary to take into account the need to assign specific values for safe withdrawals from storage, based on the hydrogeological conditions for each basin. Hence, a total value of 3,000 Mm^3/year was considered to be an acceptable depletion volume of the non-renewable aquifers, as shown in table 1 (Salem, 1997). The stated values should be considered as rough estimates that are expected to change over time as the state of knowledge on aquifer conditions improves.

Acceptable limits for non-renewable withdrawals

Basin	Withdrawal from Storage (Mm^3/y)
Gefara*	25
Jabal Akhdar*	25
Kufra & Sarir**	1300
Hamada**	150
Murzuq**	1500

* In addition to the renewed volume.
** Estimated for a minimum of 50 years.

Table 1 - Source: Salem, 1997

Total *sustainable* water supply, not including unconventional water resources, can therefore be estimated at 3820 Mm^3/year. This includes 650 Mm^3 of renewable groundwater, 170 Mm^3 of surface water which is not totally controlled at present, and 3,000 Mm^3 of non-renewable groundwater, defined as groundwater that can be extracted without introducing harmful effects to the aquifer conditions over a period of not less than 50 years (Salem 1997). Unlike demand, the supply value is considered constant over a given time horizon and includes natural water resources that are potentially available for use.

The water balance, defined as the difference between proven supply and demand at the national level is calculated for the period extending from 1999 to 2020 based on the assumptions indicated earlier. The balance should only be taken as a qualitative reflection of the state of the resource for planning purposes and long-term approach delineation. The water balance clearly reflects the progressive growth of the water deficit in response to the steady increase in demand before 2011 and the subsequent decrease thereafter.

Water balance (1999 – 2020)

Year	1998/99	2005	2010	2015	2020
Supply (Mm^3/y)	3820	3820	3820	3820	3820
Demand (Mm^3/y)	4388	4911	5658	4983	4309
Deficit (Mm^3/y)	- 568	-1091	-1838	-1163	-489

Table 2 – Source: Own elaboration

Water balance (Mm^3/year)

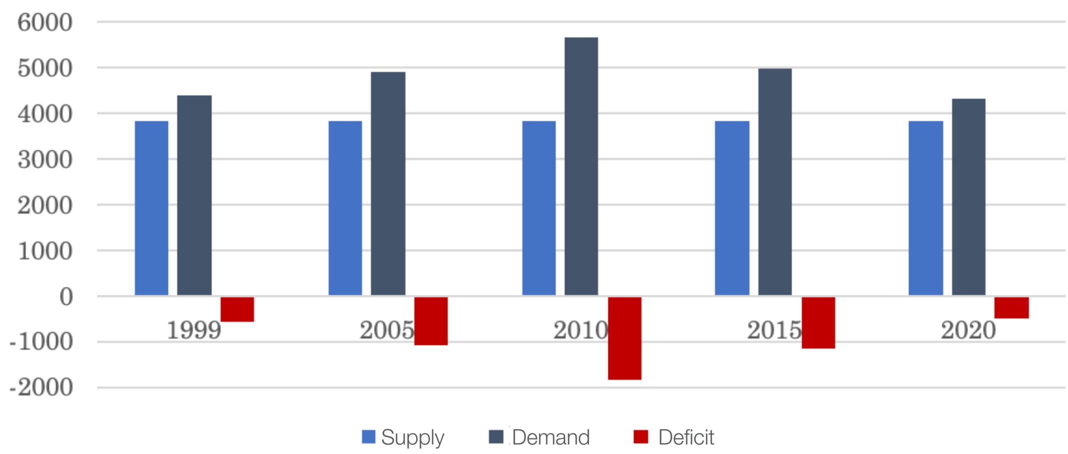


Figure 15 – Source: Own elaboration

III .

OVERVIEW OF WATER SECTOR MANAGEMENT FRAMEWORK

Water Sector Organization[9]

Management of the water sector in Libya is mainly centralized, presenting some gaps in horizontal coordination with other water related administrations. All water projects aimed at the development of groundwater resources, including those of the MmRP and municipal water supply projects must be approved by the General Water Resources Authority (GWRA). This Authority includes under its umbrella the public institutions involved in the water sector shown in Figure 16. The responsibilities of these various institutions, are presented in Appendix 1.

Organizational chart of the water sector

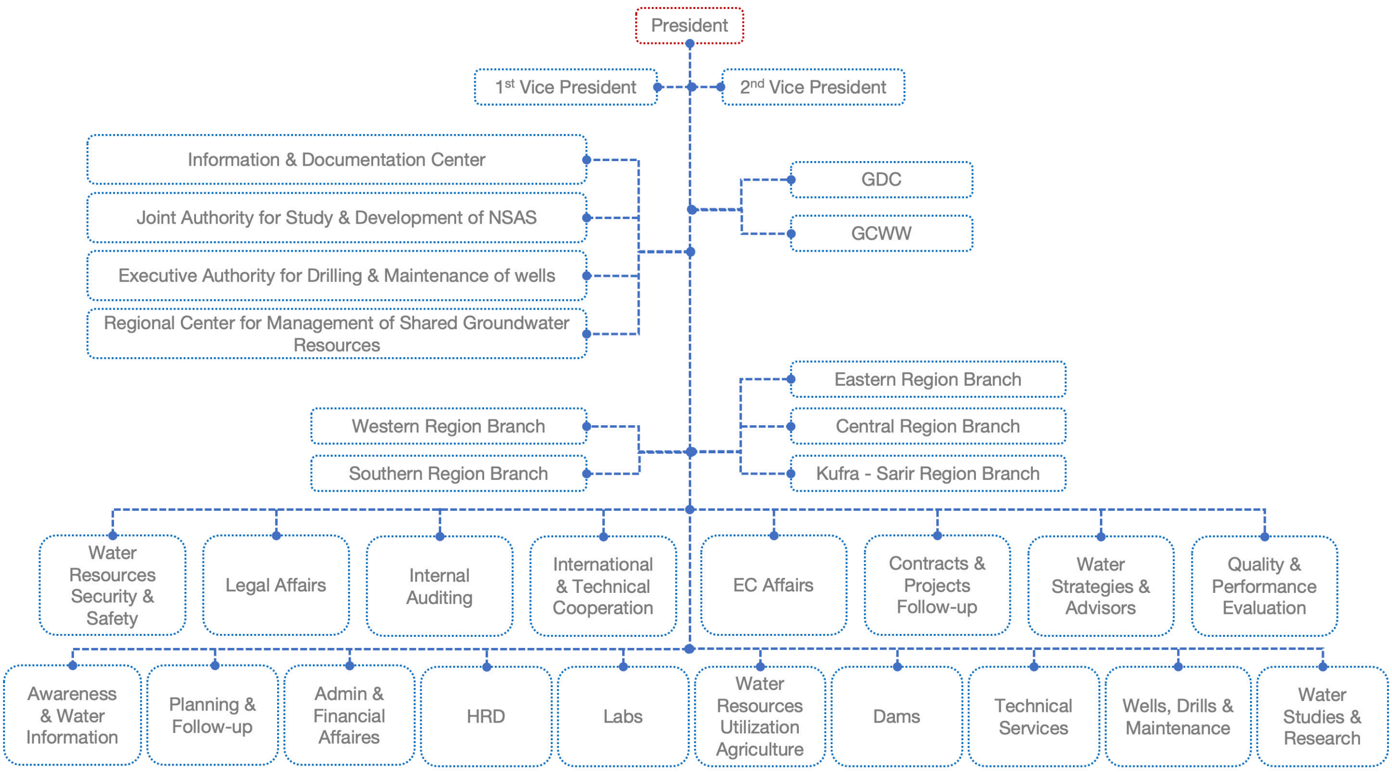


Figure 16 - Source: GWRA

The organizational structure was amended in December 2019 by the decree of the Presidential Council No. 1534/2019. Under this decree, the Executive Council and the Head of the Executive Council were replaced by a President of the Authority and two Vice Presidents. The Manmade River Authority is no longer affiliated with the GWRA but is directly under the Council of Ministers.

9 - It should be noted that important developments have taken place in Libya during the editing of this paper, including the establishment of a new unity government, which may modify the institutional framework described here.

Water Workforce Capacities

More than 20,000 people are currently working in the four main water-related institutions, amongst all kinds of categories (managers, technocrats, technicians, administrators, etc). Women's participation in the water sector workforce is not significant, accounting for just about 7% of the total workforce. The distribution of staff and women amongst the four water-related institutions is as follows: GWRA 604, of which 210 women; GDC 853, of which 44 women, GWWC 15,684, of which 1,160 women and MmRA 3,123, of which 123 women.

The outbreak of the armed conflict has severely undermined the technical capacity of the staff of the four water-related organizations of Libya. On the one hand, the intense restriction on the money allocated to these organizations, training programs has been consequently affected with a decrease and/or a disruption of available training. As an example, GCWW with about 15,700 staff, has experienced an irregular decrement in the number of people trained, from 581 in 2014 to only 24 in 2017. Besides the lack of financial resources, the reasons for the training decline stem from the lack of in-house trainers, the absence of training facilities and the coordination weaknesses between the training offices, regions and other units. On the other hand, the armed conflict has forced many people to displace within the country or abroad, subsequently reducing available staff in the organizations and, therefore obliging them to have recourse to fill vacancies (when possible) with less experienced and underqualified staff.

Legislative, Regulatory and Strategy Framework

The legislative and regulatory dispositions governing the water sector in Libya (Appendix 2) include: (i) the ownership of water, responsibility of control and management, (ii) licensing for drilling, (iii) exploitation and use, (iv) pollution control, (v) protection of water resources, (vi) allocation of water resources, (vii) municipal water supply (viii) collection and treatment of urban effluents (ix) water quality, and (x) irrigation and drainage.

The main legislation governing the water sector is the 1982 Water Law, which laid the ground for water development and use regulations in Libya and set priorities for water allocation. The law grants citizens the right to use water resources as long as they do not damage those resources and requires a permit from public authorities to use the water for drinking, industrial or agricultural purposes. In this way, the withdrawal of groundwater without a permit is prohibited as is the dumping of any liquid or solid waste into the water bodies.

The 1982 Law also covers the issue of water management. The role of water regulation is assigned to the GWRA, that is currently mandated to elaborate water policies and regulations, to carry out water resources studies and research and to supervise water development projects. The GWRA is also responsible for monitoring and evaluation of water resources.

The National Strategy for Integrated Water Resources Management 2000-2025 (NSIWRM) formulated in 2000, aims to establish the overall long-term priorities and goals. It is coordinated with the intervention of a high-level central body with full authority and means, to guide and coordinate the water related sectors' planning process. The strategy was partly implemented, many of the recommended actions were realized. However, it needs to be updated in view of recent developments and their reflection on the water sector.

THE AGRICULTURE-WATER NEXUS

As agriculture accounts for about 80% of the total water consumption, agriculture policy has a huge impact on water management and its availability. Agriculture in Libya needs important amounts of water because of the hot climate and the scarcity of rainfall. However, the selection of crops, the size of the harvest, its location and the irrigation system used are factors that have an enormous impact on the water consumption. To have a sense of the scale, irrigated land in the northern part of the country needs three time less water than that in the south. Current agricultural policy in Libya aims to achieve a reasonable degree of food self-sufficiency, where most of the products consumed in the country will be country-produced. This option is not only very costly in economic and environmental terms, but also exceeds the available water potential.

THE WATER TARIFFS

The price of water in Libya depends on its source of withdrawal. No charges apply to water extracted from privately owned wells for all uses. The current tariffs are under review and new tariffs are expected to be adopted in the near future to cope with changes in the cost of production.

The charge for the use of the water from the Man-made River Project is defined in the Decree No.218/1994 and in dependence of its use, as follows:

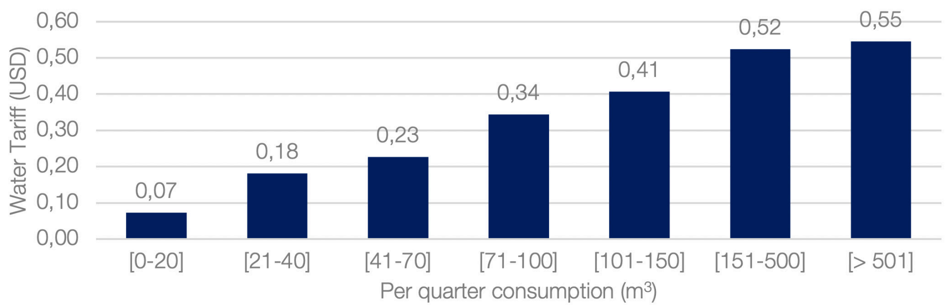
- 0.048 LYD/m^3 (equivalent to 0.034 USD/m^3) for agricultural use;
- 0.080 LYD/m^3 (0.057 USD/m^3) for domestic use, which is the tariff paid by the GCWW to the MmRP;
- 0.79 LYD/m^3 (0.564 USD/m^3) for industrial use.

The current charge for desalination water delivered by the General Desalination Company to GCWW, for domestic use is 0.86 LYD/m^3 (0.614 USD/m^3).

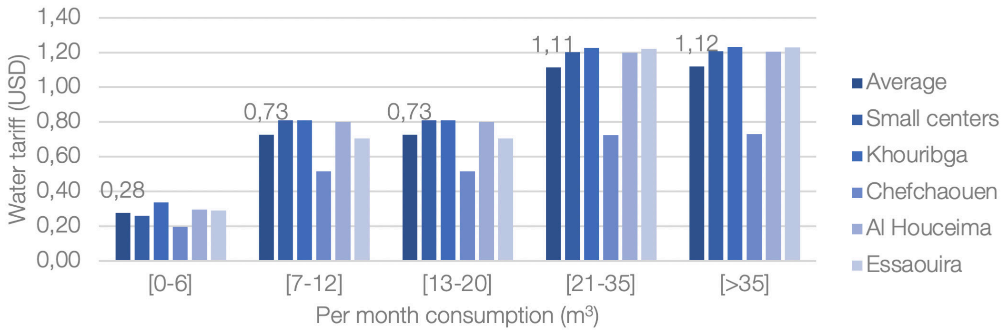
The domestic water tariff paid by users for the water supply service delivered by the GCWW is volumetric and fixed at 0.25 LYD/m^3 (0.179 USD/m^3). Conversely, in comparable regional countries such as Tunisia and Morocco, the domestic water tariff is defined by increasing block tariffs, which guarantees a minimum price to preserve the human right to access water services but penalizes high water consumption.

Box – Water Tariffs in Tunisia and Morocco for Domestic Supply

Water service in Tunisia is delivered by SONEDE, the National Utility for Water Withdrawal and Distribution. The tariff system is shared by the whole country and comprises 7 consumption blocks according to uses and quantities consumed. According to SONEDE, the Tunisian tariff scheme is based on two principles: social solidarity and accountability of large water consumers. For domestic use, the tariffs range from 0.200 TND/m^3 (0.07 USD/m^3) [10] for the first social block (0 to 20 m^3/quarter) to 1.490 TND/m^3 (0.55 USD/m^3) for the consumption block above 500 m^3/quarter.



In Morocco, water supply is provided by different service providers: ONEE, Private or Delegated and the tariff may differ according to the latter. For the domestic users covered by ONEE, the National Office for Electricity and Drinking Water, the service is charged at a price that depends on the consumption, comprising 5 consumption blocks. If water consumption is below 12 m^3 per month, the first 6 m^3 are billed on the basis of the first block. On the other hand, if consumption exceeds 12 m^3 per month, all the water consumed will be billed according to the consumption block. The tariffs vary between urban centres, but are generally between 1.79 MAD/m^3 (0.195 USD/m^3) for the first block in Chefchaouen, to 11,27 MAD/m^3 (1.23 USD/m^3) for the highest consumption in Khouribga.



10- 1 USD equivalent to 2.72914 TND and to 9.14133 MAD

Transboundary Water Management

Access to groundwater resources is essential for development in all riparian countries such as Algeria, Tunisia, Egypt, Sudan, and Chad. Hence, all countries have made groundwater exploitation a priority in their national development strategies and plans. To avoid any potential tension that might impede the rational and equitable use of shared resources, Libya has played a leading role in initiating the existing shared management mechanisms.

For the NSAS, a series of agreements have been adopted from 1992 to-date. These agreements reflect a growing willingness of cooperation amongst countries. The Joint Authority for the Study and Development of the NSAS (JA-NSAS) was formally established in 1992, and its most prominent functions include- Collection, analysis, integration and dissemination of data; Conducting complementary hydrogeological studies; Planning for the development of water resources according to agreed exploitation policies at national and regional levels; Managing the aquifer on sound scientific bases; Conducting capacity building programs; Ensuring rational use of the NSAS water; Assessing the environmental impact of water development. In addition, a Regional Strategic Action Program was formulated and approved in 2013 by the four countries, with three objectives: (i) strengthening the role and capacity of the JA in the management of the NSAS; (ii) improving the data management and exchange; and (iii) improving effectiveness of the JA-NSAS. The Strategic Action Program presents an agreed vision for the NSAS: 'to assure rational and equitable management of the NSAS for sustainable socio-economic development and the protection of biodiversity and land resources whilst ensuring no detrimental effects on the shared aquifer countries'. To achieve this vision three overarching water resources/ecosystem quality objectives were defined: (i) to improve the management of the shared aquifer involving joint regional planning and taking into account climate change, population dynamics, etc.; (ii) to mainstream environmental issues into the overall integrated management of the NSAS to reduce biodiversity loss or damage; and, (iii) to utilize the Nubian aquifer resources on a sustainable socio-economic basis. Over one hundred key management activities, actions and targets were defined to strengthen the regional and national capacity to achieve the agreed vision, with most of these actions coordinated by the Joint Authority in co-operation with national institutes and ministries[11].

On the other hand, the NWSAS study project was adopted in 1997 in Tunis, and the phase I of a regional study of the basin was launched in July 1999. A project management team consisting of representatives of the three countries, assisted by local technical teams was appointed. The project, known as SASS (Système Aquifère du Sahara Septentrional) aims in its first phase to define the hydrogeological conditions of the basin and building of a GIS-oriented data base leading to the preparation of a model able to simulate future aquifer behaviour in response to national development schemes (Salem, 2013). In 2002, the Member States (Algeria, Tunisia and Libya) reached an agreement to establish a Consultation Mechanism, with the objective to "coordinate, promote and facilitate the rational management of the NWSAS water resources." Currently, Libya is leading the Consultation Mechanism for a two-year term (2019-2021). The Mechanism's program includes several joint scientific and technical activities, mainly updating the database, setting up the aquifer monitoring network and defining the data exchange protocols between the three countries. «Phase 2 of the NWSAS project included complementary studies covering related hydrogeological components.»

11- GEF-6 PIF Template-July 2014

IV.

FINDINGS FROM THE WATER SECTOR REVIEW

Findings from the water sector analysis show that this sector still faces numerous constraints and challenges despite the enormous efforts made to date to success in water management through great investments in the development of water resources and in institutional capacity building.

Major Achievements in the Water Sector

Libya has deployed enormous investments in water sector infrastructure to meet the country's water needs. This infrastructure includes:

CONSTRUCTION OF THE MAN-MADE RIVER PROJECT (MMRP)

This large groundwater transfer project involves the conveyance of groundwater from the large sedimentary basins in the south to the coastal areas in the north, over a distance around 4,000 km[12]. The Sarir wellfield is tapping the Post Eocene aquifer and the Tazirbu wellfield is tapping the Paleozoic aquifer through boreholes of 450 to 470 meters deep. The Hasawna wellfield taps the Paleozoic aquifer of the Murzuq basin in the southwest and conveys water for around 1,140 km towards the western coastal zone, the Gefara plain and Jabal Nafusa.

MmRP scheme

Figure 17 – Source MmRP

MmRP pipeline works

Figure 18 -Source: MMRA

The Ghadames wellfield conveys water from the Lower Cretaceous aquifer to the coastal zone extending from Zwara to Zawia and other cities in western Jabal Nafusa over 775 km.

The MmRP has successfully met the need for municipal water supply to the largest cities of Tripoli and Benghazi and contributed to the development of irrigated agriculture in certain areas of the Gefara plain and other locations along the conveyance routes. The project has significantly improved the water supply situation, providing domestic water to over 60% of the Libyan population.

The MmRP consists of five phases: Phase I (Sarir-Sirte, Tazirbu Benghazi System SSTB), Phase II (Jabal Hasawna-Gefara System), Phase III (Gurdabiya / Sedada System), Phase IV (Ghadames / Zwara System) and Phase V (Kufra / Tazirbu System). phases, I and II, were completed in 1991 and 1996 respectively. The implementation of the two main phases I and II lasted 12 years from 1984-1996, with the first phase inaugurated in 1991. Phase III was also completed, and Phase IV is in the final stages of execution but was temporarily halted pending resumption when local conditions are suitable (Fig,17). In its final stage, the MmRP is expected to deliver nearly 6.5 Mm^3/day, about 2.2 billion m^3/year.

12- Total distance from Tazirbu to Benghazi and to Sirte is around 1200 km, and about 1140 km for Phase II in addition to 200 km to connect Phase I and Phase II, plus around 775 km for the Ghadames wellfield to the western coastal area making the total more than 3,000 km in addition to over 1200 km of collection lines in the wellfields.

Originally, 75% to 80% of these resources were planned to be allocated to agriculture; however, this ratio has witnessed continuous change in favour of domestic use.

A special body, the MmRP Authority, oversees the development and management of the project. According to the Authority, the cost of the project is 12 billion Libyan Dinars[13]. It has been entirely funded from state funds and local taxes.

All the wellfields of the MmRP were studied in detail through several exploratory wells, long duration pumping tests, accumulation of historical data on groundwater withdrawals, water quality, piezometry and the overall aquifer behaviour. Mathematical models were then constructed to simulate drawdown within the wellfield area and its extension outwards. Several criteria were considered while modelling the MmRP wellfields, mainly not to exceed an acceptable pumping head and not to impose extra drawdown on nearby settlements and projects. The least impact scenario is identified and later implemented. These criteria also control the project lifetime and reflect the situation within the wellfield boundaries and is not an indication of aquifer depletion.

CONSTRUCTION OF DAMS

Libya has constructed 18 dams (Appendix 3) to store rainwater and ensure flood protection of local communities, with a total storage capacity of nearly 375 Mm3. Water stored behind these structures is used for agricultural and industrial purposes, and in some cases for domestic consumption.

DEVELOPMENT OF LARGE IRRIGATION SCHEMES

The MmRP has allowed the development of large irrigation schemes in the north of the country, which have resulted in significant increase of agricultural production. The government has invested in seven major irrigation projects, the largest of which is in the Gefara plain south of Tripoli, over an area of about 3,300 hectares, divided into 665 farms of various crops: citrus, wheat, barley and vegetables. It was planned to millions of olive and palm palm trees in different locations, but the current unstable conditions disrupted the realization of this project.

CONSTRUCTION OF MUNICIPAL WATER SUPPLY AND SANITATION INFRASTRUCTURE

Significant municipal water supply and sanitation infrastructure has been constructed under the National Program for Water and Sanitation. The Program was launched in 2005 for an intermediary period of three years before finalizing water and wastewater plans for all municipalities. The program was centrally managed by the Ministry of Planning and was later transferred to the newly formed Housing and Utilities Board in 2006 to be replaced later by the Integrated Utilities Program for the 400 cities and urban areas of Libya. Under this program, water supply and sanitation projects have been developed for almost all urban communities. Sanitation facilities, including collection, transport and treatment of urban effluents have been constructed along with municipal water supply networks.

Water supply and sanitation access ratio

Figure 19 - Source: GCWW

In total, more than 6,962 km of sewage collection and sewerage conveyance network and 74 sewage treatment plants have been completed. Very few of these plants are presently operating. As part of the program, other projects are being launched or are programmed to serve more than 400 small urban communities. Despite the lack of accurate data in recent years, current rates of access to water and sanitation networks are estimated at nearly 64% and 45% respectively. The consequences of the lack of access to water and sanitation services affect particularly the physical well-being of women and children, who are primarily responsible for the management of household water supply, sanitation, and health.

Constraints and major Challenges of the Water Sector

The analysis of the water sector in Libya made it possible to identify its main constraints and challenges, which are particularly technical, institutional, and regulatory. These major constraints and challenges include:

13- The cost in USD depends on the exchange rates applied for the different contracts.

A growing gap between water supply and demand, aggravated by frequent occurrence of droughts and severe water shortages;

- A growing water demand caused by demographic growth;
- The growing use of water by the agriculture sector;
- Considerable water losses in the municipal water supply and irrigation distribution systems, aggravated by the water related infrastructure degradation;
- Depletion of coastal groundwater aquifers, and continuous advances of the seawater intrusion front;
- Disruption of operation and maintenance of the hydraulic infrastructure;
- Insufficient funds for the water sector associated with inadequate water pricing and weak water cost recovery;
- High staffing rotations leading to lack of on-job experience and weak competences within the staff;
- Gaps in water resources monitoring and evaluation, and in water information system;
- Absence of long-term water sector planning, defining water related sub-sectors long-term priorities and goals;
- Gaps in institutional and regulatory frameworks.

GROWING GAP BETWEEN WATER SUPPLY AND WATER DEMAND

The rapid growing water demand in Libya puts great pressure on the country's water resources. Despite the authorities' efforts to invest in the development of water resources, water demand continues to exceed water supply, resulting in increasing water deficit. Water gap in 2010 was estimated to be about 1,838 Mm^3/year. It is anticipated that unlicensed wells, green water[14] and inaccuracy in the estimations contribute to the balance.

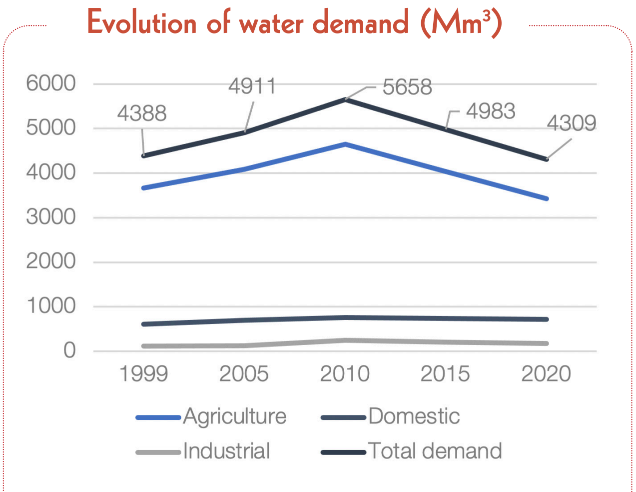


Figure 20 - Source: GDC, GCWW, own elaboration

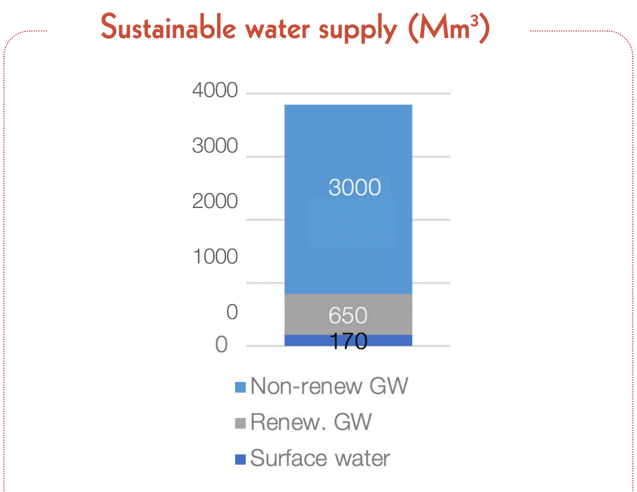


Figure 21 - Source: Salem, 1997

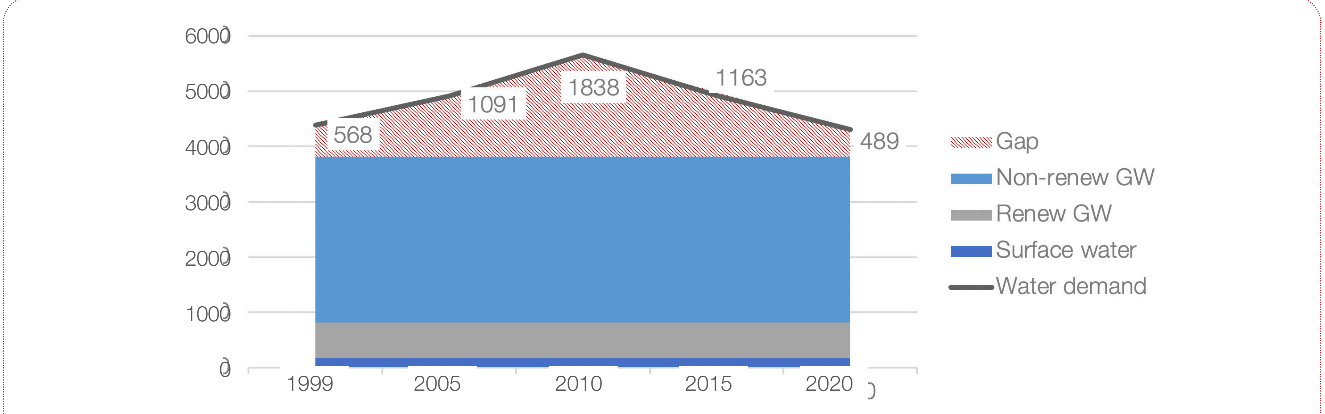


Figure 22 - Sources: Own elaboration

Under normal circumstances (prior to 2011), the gap between the water demand and the sustainable water supply was rapidly increasing over time. It is also noted from figures 20, 21 and 22 that: i) available water supply,

14- Green water is the amount of rainfall that is either intercepted by the vegetation or enters the soil and is picked up by plants and evapotranspired back into the atmosphere. Some 65% of all rainwater is cycled through the green water cycle and is the water source for rainfed agriculture excluding unconventional water resources, are steady but water demand exceeds water supplies with a deficit increasing sharply with time, under normal circumstances; ii) agriculture is responsible for about 80% of the total withdrawals and iii) agriculture accounts for most of the increment in water withdrawals. The water deficits are compensated by unsustainable water withdrawals, which contribute to freshwater depletions and seawater intrusions with detrimental impacts, and to a minor extent, by unconventional water production.

DEMOGRAPHIC GROWTH

Since the first census carried out in Libya in 1931, the country has experienced different trends regarding demographic growth. According to different sources, including UN sources, World Bank data and National Census[15] Report, population in Libya grew rapidly from 1931 to 1973, reaching a maximum population growth rate of 4.12% in 1973 (2.3 million people); since then, the growth rate decreased to 2.54% in 1995 (5 million people). Since 1995, population growth has stabilized to about 1.5%, experiencing a drastic deceleration since the beginning of the Libya crisis in 2011. If the pre-conflict trend remains constant for the next ten years, it is expected that population will grow from 6.98 million (2020), including 1 million people externally displaced) to 8.1 million in 2030. Libyan population is mostly young, with 42% of the population under 24 years old and 47% between 25 and 54 years old, with an average age of 29.4 years in total. 46.7% of the total population are women. Despite the vast territory available, Libyan population resides mostly in 10% of the territory, primarily along the coast. About 90% of the population is urban, mostly concentrated in the four largest cities of Tripoli, Benghazi, Misrata and Zawia. While demographic growth rate was zabove trends of other countries in the same region before 1990, the current rate for the last 25 years is similar to the rate in Morocco and Tunisia, for example.

Migrants make up just over 12% of the total population, according to UN data (2014) the African countries with the highest proportion of

Census Year	1954	1964	1973	1984	1995

Table 3

migrants. Libya presents a complex displacement scenario, with people displaced inside the country, people who have returned home, refugees and asylum-seekers and migrants. Partly this is caused because Libya was a destination country for economic migrants before the 2011 crisis and still remains a hub for transit migration to Europe due to its location. This complex scenario puts additional pressure on water and sanitation services.

The following table summarizes the population growth in Libya since the first official census in 1954, three years after independence in 1951. It includes Libyan and non-Libyan residents in the country.

Population growth in Libya

Census Year	Population	Annual Growth Rate	
1954	1,088,882	Period	GR
1964	1,564,369	1954 - 1964	3.69%
1973	2,249,237	1964 - 1973	4.12%
1984	3,642,576	1973 - 1984	4.48%
1995	4,798,065	1984 - 1995	2.54%
2006	5,657,692	1995 - 2006	1.51%

15- It is important noting that no official statistics are available since the last census of 2006.

As previously mentioned, Libya relies essentially on its groundwater to secure its municipal and agricultural water needs. In general, groundwater abstractions largely exceed renewable water, which is draining the water table and contributing to seawater intrusion in the coastal aquifers. The current groundwater withdrawals amount to nearly 4,091Mm³/year, depleting the non-renewable groundwater storage by nearly 3,441 Mm³/year.

Groundwater depletion in the Gefara plain aquifers

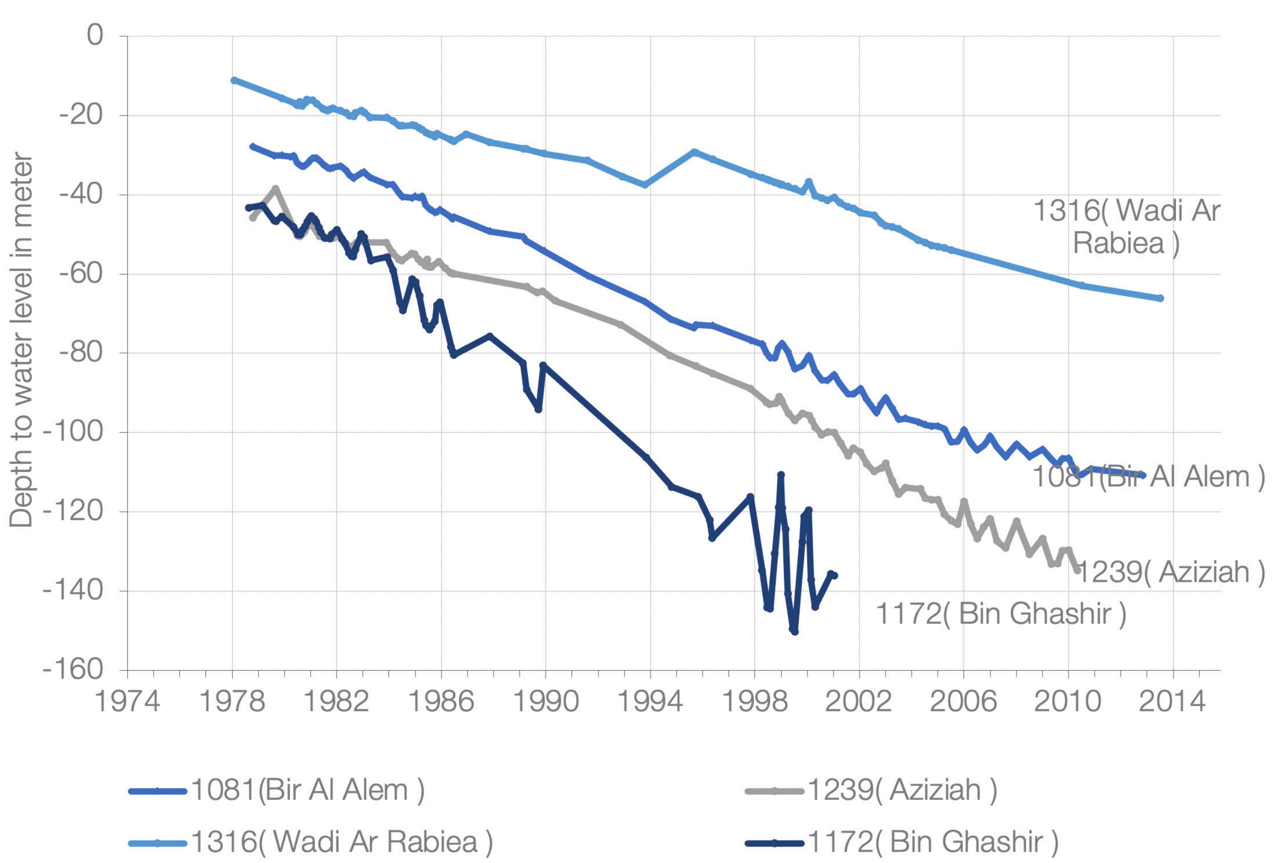


Figure 23 - Source: GWA files

The economic and social costs resulting from the current trend of groundwater exploitation will increase over time, as: (i) irrigated farmlands may be affected due to increasing water shortage and high soil salinity, and (ii) mobilizing additional water resources, at a higher cost, will be inevitable to meet water needs of local communities.

The current groundwater depletion situation is to be blamed not only on the users but also on the relevant authorities, as they are not able to enforce the laws and regulations that control groundwater withdrawal. Although the regulations in place are strict regarding exploitation from the affected areas which are normally placed under either complete or restricted prohibition, violations are difficult to avoid, in the absence of a strong law enforcement system. Nevertheless, there are many gaps in the existing groundwater regulatory framework that need to be filled for an effective control of groundwater abstraction.

The coordination with riparian countries for protecting the transboundary aquifers from over-exploitation and from pollution is also crucial to enhance the sustainability of the groundwater resource.

WATER LOSSES IN MUNICIPAL AND IRRIGATION DISTRIBUTION SYSTEMS

Figure 24 - Source GCWW, BAH, GWRA

No precise data on water losses from the municipal and irrigation distribution systems are available. According to GCWW (2019), municipal water distribution losses amount to 30%. In 2007, Booz-Allen-Hamilton (BAH) estimated at 35% the Unaccounted-for Water[16] (UFW), which includes losses due to network leakage and illegal connections within a region divided by the total number of connected populations within that region. Water losses in the irrigation distribution systems, particularly for the private sector, are also not well defined and are usually confused with irrigation efficiency. The Irrigation and Drainage Directorate in GWRA stated that distribution losses, though not accurately measured, fall between 35 and 40%. The lack of proper maintenance and repairs, as well as the extensive damage to infrastructure, may indicate that water distribution losses have increased in recent years.

RISKS OF SEAWATER INTRUSION IN COASTAL AQUIFERS AND GROUNDWATER QUALITY DETERIORATION

The impacts of seawater intrusion due to excessive coastal groundwater depletion resulted in a significant groundwater quality deterioration. In many cases, local groundwater became unsuitable for domestic, industrial, and agricultural uses because of high salinity levels.

The development of irrigated agriculture in the coastal region in the Gefara plain and the Jabal Al Akhdar region, together with a proliferation of illegal well drilling by private farmers led to depletion of the coastal aquifers. Indeed, in some coastal areas, where both the population and agricultural activities are concentrated, the freshwater-saltwater interface has progressed more than 15 km inland. Consequently, salinity levels have increased significantly from less than 300 parts per million (ppm) to over 15,000 ppm in some points.

Poor and inefficient irrigation management made this situation worse, as it accounts for most of the water wastage. Although attempts were made to reduce the area under water-intensive crops, little has happened, and groundwater levels continue to fall. This, in turn, has resulted in seawater intrusion in coastal aquifers. Groundwater use for irrigation is not effectively managed and the expansion of irrigation continues without control. Investigations based on satellite imagery have revealed that the area under irrigation continued to grow even in the vulnerable coastal regions prior to 2011. The rate of growth has since slowed down considerably and even reversed. In addition, a gradual increase in the salinity levels of the coastal aquifers will result in the accumulation of salts in the soil, which leads to a decline in agricultural productivity.

THREATS OF WATER POLLUTION BY WASTE WATER EFFLUENTS

Anthropogenic water pollution is reported in some areas in Libya. It appears to be due to the disposal of untreated effluent generated by certain urban agglomerations, either because no sewerage network and wastewater treatment plants exist, or because the existing wastewater treatment plants are not functioning properly.

THREATS OF WATER POLLUTION BY AGRICULTURAL ACTIVITIES

This pollution of water resources is reported in some areas of the country, particularly in certain irrigation schemes located in the north, where high levels of nitrates are observed (Ennajeh et al., 2018). This pollution appears to be due to the intensive use of nitrogen fertilizers in agriculture.

16- In this document, the difference between Non-revenue water (NRW) and Unaccounted-for water (UFW), is that NRW includes authorized unbilled consumption (as, for example, the water used for governmental buildings or firefighting).

INADEQUATE WATER PRICING AND WEAK WATER COST RECOVERY

The Water law stipulates that water is a publicly shared resource and that every citizen has the right to use it for different purposes, if it shall not cause damage to the water body, its source or the adjacent lands and installations. Under Law No.3 of 1982, water is a public ownership and can only be exploited by a license which defines the amount and duration of use. By law, each person is obliged to protect water and not to overuse it. This principle forms the basis of all water strategies and policies in Libya, including the water-pricing policy. The right of all citizens to access drinking water is guaranteed by law. Water infrastructure projects, including construction, operation and maintenance are state funded.

A tariff structure for municipal water supply exists, and according to the law, municipal water must be metered and progressive water levies are charged. However, the charged levies are not intended to recover the investment costs nor the total costs of operation and maintenance. They are rather intended to partially offset operating and maintenance costs. As an indication, the desalinated water is charged to GCWW at 0.86 LYD/m3 (US$ 0.61) which is about half the average cost of production including depreciation, operation, and maintenance. The charge to the consumer is however subsidized and is 0.25 LYD/m3 (US$ 0.18). Irrigation water is not charged except for irrigation schemes where water is delivered by the MmRP Authority. The fees charged are 0.048 LYD/m3 (US$ 0.034) which is much lower than the cost of investment and operation, estimated at more than US$ 0.32/m3. Farmers pay only the cost of energy used for water delivery, and this energy is also subsidized. Groundwater abstractions from private wells are not controlled and therefore not charged. Finally, the water service billing system is irregular and sometimes non-existent.

DEGRADATION OF THE HYDRAULIC INFRASTRUCTURE

The state of the infrastructures prior to 2011 was already considered inadequate due to aging and lack of adequate maintenance. The armed conflict has aggravated this situation since 2011. Although accurate data are not available, the reported massive damage suggests a serious deterioration of the infrastructure.

DEGRADATION OF MUNICIPAL WATER SUPPLY AND SANITATION INFRASTRUCTURE

The political instability in Libya in recent years has resulted in significant degradation of municipal water supply and sanitation infrastructure due to lack of adequate operations and maintenance services, and aging equipment that increases losses and risk of pollution. This situation has disrupted municipal water supply and sanitation services due to frequent power cuts and the unavailability of chemicals, chlorination, spare parts for pumping stations and water treatment equipment. In addition, the poorly equipped laboratories preclude the monitoring of water and wastewater quality. Furthermore, practically no wastewater treatment plants are functional and most pumping stations have suffered serious damage. Many wells which require either routine maintenance or replacement remained unrepaired due to lack of funds, spares, and absence of contractors.

DEGRADATION OF SEAWATER DESALINATION PLANTS

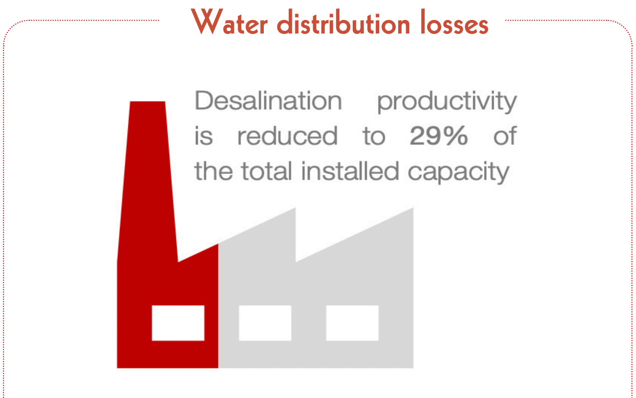


Figure 25 - Source Own elaboration

Currently, only 7 desalination plants are operating with actual productivity reduced to 29% of their total design capacity. A main reason behind this poor performance is the insufficient funds allocated to the management of the desalination plants, which delays flow of spares, chemicals, and disrupts overhauls, in addition to conflict related interruptions of works executed by expatriate companies. Other reasons behind the poor performance are associated to the frequent interruptions of fuel and electrical power supply. Moreover, all desalination plants exceeded their design life span and are suffering from aging and poor maintenance.

DEGRADATION OF IRRIGATION WATER SUPPLY INFRASTRUCTURE

In the large public irrigation schemes, equipment and installations (boreholes, pumping equipment, pipelines, etc.) have been damaged due to lack of maintenance, resulting in considerable irrigation water losses estimated at more than 50%.

CONSTRAINTS ASSOCIATED WITH OPERATION AND MAINTENANCE OF THE MmRP INFRASTRUCTURE

The MmRP complex water distribution system requires special technical skills for its operation and maintenance. Since the outbreak of the armed conflict in the country, the management of the project's facilities runs into numerous technical and managerial difficulties. In addition, the MmRP has suffered several and serious damage following acts of sabotage in phases I and II.

GAPS IN WATER RESOURCES MONITORING AND EVALUATION

The General Water Resources Authority is running a national Geographic Information System (GIS) controlled database for the water sector called Hydro-Manager. The database stores water supply data generated by the MmRP and municipal water supply and sanitation data produced by GCWW and GDC companies. This database also includes data on transboundary aquifers: NSAS & NWSAS. However, management of this database is currently hampered by numerous impediments such as:

- Gaps in data: data is dispersed, fragmented, discontinuous and incomplete;
- Gaps in the water resources monitoring network: few piezometers are monitored regularly;
- The NARIS database (the Nubian Sandstone Aquifer System) is not updated;
- Gaps in technical skills for adequate database management;
- Lack of assessment indicators to regularly evaluate the performance of the water sector;
- Inefficient national program for water resources monitoring and evaluation.

GAPS IN THE WATER SECTOR INSTITUTIONAL AND REGULATORY FRAMEWORKS

The main gaps reported in the institutional and regulatory frameworks include:

- High staff rotation, causing weak institutional capacity and poor knowledge management and lessons learnt from previous activities and interventions;
- Weak regulation enforcement;
- Lack of private sector involvement and/or participation in the water sector through public private partnerships (PPP);
- Weak involvement of the water users in water resources management, particularly in the irrigation sector;
- Low recovery billings for water and sanitation services;
- Insufficient sensitization programs to raise awareness on the economy of water usage;
- Lack of incentives to encourage water saving;
- Absence of long-term National Water Management Policy: all water related institutions prepare and implement their sector strategies and action plans, in absence of a clear national water policy and strategy that will define the overall long-term priorities and goals. Although it was strongly recommended in the 2000-2025 strategy to establish a Supreme Water Council, there is still an absence of a high-level central body with full authority and means to guide and coordinate the planning process of the water related sectors. The integrated approach which was clearly adopted in the first National Water Resources Management Strategy formulated in 2000 has not yet been fully implemented.

CLIMATE CHANGE ADAPTATION MEASURES

The effect of climate change, coupled with rising water demand and limited water resources will put additional pressure on Libya's depleting groundwater resources. Therefore, sound water management practices must be adopted and applied alongside the development of non-conventional water resources alternatives and the reorientation of irrigation water policies. Current practices and strategies for water resources management need to be revised to adapt to climate change.

V.
POST-CONFLICT RESPONSE

Post-2011 Crisis

Since 2011, Libya has been going through a long period of civil unrest with periods of armed conflicts that have resulted in the rapid deterioration of the water supply and sewerage with serious negative impacts on a high percentage of the population. Water shortages are likely to increase due mainly to infrastructure damage, depletion of chemicals and spares, interruption of stock supplies, and decreasing Libya's ability to generate and distribute electricity.

Water becomes a casualty in Libya's conflict

During the ongoing Libya crises, the water system pipeline, some of the production wells, power supply substations, transmission lines, transformers and other related facilities have been frequently damaged to push through the political demands, endangering the population. Recently, in April 2020, more than two million people who live in Tripoli were suffering from water cuts for almost a week, as a pressure tactic initiated by a group in Shwerif area.

Insecurity and armed conflict, which precludes data collection, are the major challenges facing a sound assessment of the current situation. Data collection is a dynamic and interdisciplinary process that requires a high level of coordination with regular compilation, updating, verification, and validation of data. This process is hindered by the challenges inflicted by the current instability and the damage directly caused to the measurement equipment. As a result, the latest official data about water supply and sanitation coverage dates back to 2009.

Therefore, the current situation of water supply service cannot be correctly assessed. The situation is critical, based on reported dysfunction in desalination plants, pumping stations and the Man-made River Project, as well as electricity shortages. To fill in the gap, water trucks (at high costs and uncertain quality level), and illegal private wells are presumably supplying water to an important sector of the population.

The General Desalination Company operates 7 plants spread all along the Mediterranean coast. The functionality of seawater desalination plants declined because of critical shortages of chemicals in addition to lack of major overhauls. The stoppage will have serious impact on the coastal population, particularly for the towns that are not supplied by the MmRP. It is worth noting that the operation of the desalination plants after stoppage will take a long time to regain full design capacity and at higher rehabilitation costs.

Additionally, the MmRP, which supplies water not only for agriculture but also for 60% of Libyan households, is facing serious damage caused by the armed conflict and vandalism. Consequently, water losses are presumably higher than they were prior to the conflict (accounting for 50% in 2012).

Due to electricity shortage and the low level of monitoring and operation, most of the water networks and pumping stations are no longer functioning.

The situation is similar for most of the wastewater treatment plants, managed by the General Company for Water and Wastewater, which remain practically out of service due to lack of major overhauls. Additionally, they suffer frequent and prolonged power cuts from the national power grid. Furthermore, some sewage pumps need to be repaired or replaced, otherwise, wastewater will presumably flood low areas in the cities (as it has already happened in Benghazi and Sabha), with serious health and socio-economic consequences.

Short-Term Response

The main objective of the short-term response in the water, sanitation and hygiene sector is to reduce public health risks by guaranteeing a minimum level of services for drinking water and sanitation, while restoring the services to pre-conflict level.

Short-Term Goal #1	Definition of a Priority Action Plan for infrastructure rehabilitation
Short-Term Goal #2	Develop a rehabilitation strategy for water and sanitation services and infrastructures
Short-Term Goal #3	Guarantee the functionality of water supply systems: desalination plants, water supply and pumping networks and MmRP
Short-Term Goal #4	Guarantee the functionality of the sanitation systems: wastewater treatment plants, sewerage and pumping systems and on-site sanitation when needed
Short-Term Goal #5	Raise awareness about hygienic good practices

The actions to be undertaken involve (not exclusively):

- Assessing the current state of water and sanitation infrastructure;
- Drafting and validating an action plan with action prioritization;
- Purchaising chemicals needed for desalination plants;
- Repairing or Purchaising pumps for water supply and sewerage networks;
- Providing power needed for water and sewerage systems;
- Examining, repairing and renovating water networks to decrease leakages;
- Strengthening national capacities.

VI.
WATER STRATEGY

Vision and Objectives

The sector vision for Libya is to secure equitable and sustainable use and management of water resources for socio-economic development, regional cooperation, and the environment.

The main objective of the water strategy is to improve the water resources management to meet the present and future water needs of the country, to promote sustainable, green and inclusive socio-economic growth and development and to contribute to the achievement of peace and security. The proposed water management approach is comprehensive and integrates the three water uses stipulated in the water law, industrial, agricultural, and domestic, while also considering the needs of the ecosystem. This approach will lead to a reflection exercise on agriculture water management and therefore, on how to achieve a great deal of food security in the country.

The proposed sector strategy outlines the following strategic objectives:

- By 2030, achieve universal and equitable access to safe and affordable drinking water supply and sanitation services;
- By 2040, achieve a sustainable balance between water demand and water supply, minimizing non-renewable water resources withdrawals.

The objectives settled are aligned with the national development plans as well as with the Agenda 2030. Particularly, the proposed strategy contributes to Sustainable Development Goal (SDG) 6, ensure availability and sustainable management of water and sanitation for all; SDG 14, conserve and sustainably use the oceans, seas and marine resources for sustainable development; and SDG 15, protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss, amongst others.

Programming Principles

Eight programming principles are defined to guide the water and sanitation sector strategy (Figure 27).

1. NO ONE LEFT BEHIND

In July 2010, the United Nations General Assembly explicitly recognized the human right to water and sanitation, acknowledging that these are essential to the realisation of all human rights. In the same way, universal water and sanitation coverage is specifically included in the Sustainable Development Goals. To leave 'no one behind', independently of demographic or socio-economic differences, drinking water and sanitation services need to be accessible, affordable, acceptable, and available for everyone.

2. RESILIENT SOCIO-ECONOMIC DEVELOPMENT

The role of the water and sanitation sector in peacebuilding, disaster risk reduction, climate change adaptation and environmental protection is fundamental to building resilience. The negative effects of climate change and environmental degradation contribute to compound these risks. The sector strategy promotes a solid, risk-management based, socio-economic development.

Programming principles

Figure 27 - Source: African Development Bank Group

3. WATER DEMAND MANAGEMENT

Meeting the challenge of water scarcity requires both a supply management strategy, coupled with vigorous demand management involving comprehensive reforms , as well as actions to optimize the use of existing supplies. La coma doit être à coté de reforms: reforms, However, in the past, the Libyan government has prioritized water supply management without neglecting water demand management, taking full account of the limited renewable resources and its socio-economic and environmental impact, as clearly highlighted in the previous strategies.

Water demand management requires the recognition of the socio-economic value of water in different uses along with attention to cost recovery, with emphasis on affordability and securing the human right of access to water and sanitation. Since water for agriculture accounts for 80% of total water consumption, optimizing irrigation techniques, crop selection and ultimately, selecting an appropriate agricultural policy is essential for successful demand management.

4. POLLUTER PAYS

Parties responsible for producing pollution (industries, agriculture, or households) are responsible for paying for the damage done to the natural environment. In other words, polluters are responsible for the treatment costs associated with the used water, to discharge it in the same conditions as it was withdrawn. The polluter pays principle has been emphasized in both the Water Law (3/82) and the Environmental Law (15/2003), but the problem lies in the application of both laws.

5. STRENGTHENED NATIONAL INSTITUTIONS

Effective sector institutions are pre-requisites for the delivery of quality water and sanitation services. Support for strengthening the national capacities must be accompanied by reforms of the related fields such as fiscal policies, budgetary allocation procedures and decentralization processes.

6. PARTICIPATION AND CITIZEN ENGAGEMENT

Public participation contributes to improving appropriation and enhancing development outcomes. Moreover, public participation can improve the provision and quality of public and private services, enhance public financial management, improve transparency, accountability, and promote social inclusion, which leads to a significant improvement in people's lives.

7. GOOD GOVERNANCE

As access to water and sanitation is a human right, water and sanitation services should always respond to public interest requirements. This requires strong commitment to integrity, ethical values, and the rule of law. Water and sanitation governance refer to the political, social, economic, and administrative systems in place that influence water's use and management. Governing water and sanitation sector include formulation, establishment and implementation of sector policies, legislation and institutions, and clarification of the roles and responsibilities of the government, civil society, and the private sector.

8. INTEGRATED WATER RESOURCES MANAGEMENT

The use of the water resource fundamentally interconnects all the socio-economic sectors, in addition to the environmental needs. The uses of water are interdependent when water is used for one purpose, it cannot be used at the same conditions for another one, as the resource has already changed in quantity, quality or availability in time or space. Indeed, water use for agriculture means less freshwater (and potentially more polluted) for drinking or industrial use; contaminated domestic water pollutes surface and groundwater resources and threatens ecosystems; in turn, water in a river to ensure the protection of fisheries and ecosystems, means less water available for agriculture. The Integrated Water Resources Management is defined by the Global Water Partnership as a process which promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment.

Strategic Focus Areas

1. MANAGING WATER DEMAND

The water demand management refers to all the measures aiming at increasing technical, social, economic, environmental, and institutional efficiencies in all sectoral uses. Water demand management targets water loss reduction and uses optimization for a better satisfaction of the current and the future demand[17].

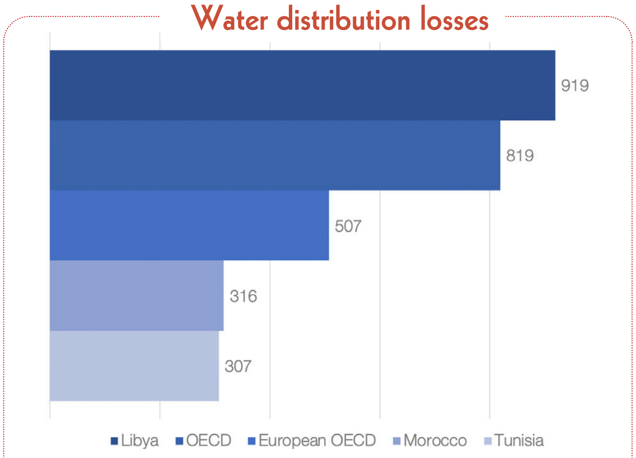


Figure 28 – Souce: OECD, Own elaboration

Estimated water withdrawal in Libya in 2010 was 919 m^3 per capita per year; above the average consumption of 819 m^3 per capita per year in the OECD countries. and well above the 507 m^3 per capita per year of the European OECD countries, in the same year. When comparing the data to other countries in the same region, with similar socio-economic context and water stress, per capita water consumption in Libya is three times higher than that of Tunisia and Morocco. Beyond a low per capita consumption of about 300 m^3 per year per inhabitant, these two countries, are also performing well in water and sanitation services and in the development of the agriculture sector both for internal consumption and export. Hence, this high-water demand should not be acceptable in a country like Libya -one of the highest

water-stressed countries worldwide. In 2020 the withdrawal has been reduced to 743 m^3 per capita per year in response to the considerable reduction in the agricultural and domestic water demand.

1.a - Reduction in Network Losses

Significant water savings can be achieved by gradually reducing overall water losses in domestic and irrigation water networks. Water losses in these sectors are estimated –prior to Libya's conflict- at about 30% to 35% for domestic consumption and about 35% to 40% for irrigation, which represents about 1,856 to 2,126 Mm3 only for the year 2010. As irrigation accounts for about 80% of total water demand, a substantial part of water may be recovered from the irrigation network.

17- UNEP-Mediterranean Action Plan. Regional Activity Center

1.b - Improve Water Use Efficiency in Irrigation

In the field of irrigation, there is a great potential for water savings and improving water productivity through improved irrigation practices and the development or the introduction of improved high yield varieties and high value crops. Traditional irrigation practices currently applied in some agricultural areas result in considerable water losses, as the potential evapotranspiration is very high under the arid conditions of Libya. Given that almost 80% of the water resources mobilized are allocated to irrigated agriculture, the efficient water use in irrigation would have a more significant impact on the overall water balance, generating significant water savings.

The water saving potential may be recovered through the implementation of the following measures:

- Gradual replacement of existing traditional irrigation systems with modern localized irrigation techniques;
- Promotion of weather watering based on temperature and soil conditions;
- Efficiency improvement in irrigation water delivery systems; restrictions on further expansion of irrigated perimeters, particularly in the arid and semi desert lands;
- Prioritizing crops of lower water consumption.

The water gains which may be achieved by promoting the use of drip irrigation techniques have already been demonstrated in some parts of Libya and in the Gefara plain. In these places, significant irrigation water savings have been achieved, in addition to improving agricultural productivity.

The spread of drip irrigation began during the eighties and grew at an accelerated rate with the spread of protected crops and the establishment of a broad industrial base at the public and private sector level to manufacture some parts of the system. Drip irrigation reached its peak of expansion in the nineties with the implementation of the Water Investment Authorities of the MmRP and the establishment of the palm and olive projects in various regions. Like most agricultural activities, the area under drip irrigation has decreased significantly from around 60% of the total area under irrigation in the year 2000 to about 45% today.

The large-scale promotion of these water-saving irrigation techniques may necessarily require implementation of the following measures:

- Establishment of incentive mechanisms to encourage farmers to introduce these irrigation techniques;
- Organization of farmers in public irrigated perimeters into Associations of Agricultural Water Users and establishment of farmers' irrigation technical assistance bodies; and
- Expansion of the local manufacturing of drip irrigation equipment.

1.c - Cost Recovery

Water and sanitation are economic and social services that need to be adequately funded to cope with population growth in a satisfactory manner and in accordance with the approved standards. It means that there is a need to balance the human right to water and sanitation and the cost of providing these services. Adequate financing of water projects is important to sustain and extend the water and sanitation system. The most common sustainable sources for financing water and sanitation services are, what is commonly known as the 3 Ts: Tariffs, Taxes and Transfers. The fees for providing water and sanitation services in Libya are very low, so revenues do not even cover operation and maintenance costs, let alone rehabilitations or infrastructure investments. This creates a high dependence on subsidy from central government to provide an adequate service. As stressed by the OECD (2009), "well-designed tariffs are crucial for achieving sustainable cost recovery while ensuring affordability". In this case, a well-designed pricing scheme blending the 3 Ts will decrease the financial dependency of the sector on subsidies and enhance sustainability. A larger share of tariffs will reduce the financial burden on the government while providing incentives for more efficient use of water resources. Cost-recovery is not only an instrument for improving water usage efficiency, but also for improving and expanding services while enhancing social equity and securing the service sustainability.

Sustainable sources for financing water and sanitation services and expanding services while enhancing social equity and securing the service sustainability

- Tariffs are defined as users' fees or contributions. Service providers can levy such fees for providing access to a service (*i.e.* connection fees), for delivering the service or for other purposes (such as meter rentals, penalties, etc.)
- Taxes refers to funds raised by national, regional, or local governments through the tax base, which are subsequently diverted to the water and sanitation sector. While subsidies or grants are the most visible form of tax funds directed to the water and sanitation sector, other forms may include tax rebates, soft loans, transfer from local government housing taxes, subsidised related services, etc.
- Transfers are payments that come from foreign sources, as official development assistance.

The water pricing scheme needs to be reviewed to achieve sustainable cost recovery, which has been proved more realistic than full cost recovery, even in the most developed countries (OECD, 2009). Sustainable cost recovery is summarized by the following three characteristics:

1. An appropriate combination of tariffs, taxes and transfers to finance operation and maintenance costs, as well as some capital costs, and to leverage other forms of financing;
2. Predictability of public subsidies (taxes) to enhance investments;
3. Tariff policies that promote affordability and equity, while ensuring financial sustainability for service providers.

1.a Awareness Raising and Water Conservation Programs

Raising awareness of water users about the importance of water conservation is a particularly important step towards ensuring implementation of effective water demand management. Investing in awareness programs is not only beneficial, but also necessary for sustainable water demand management. For this purpose, awareness programs need to be carefully prepared, well targeted and implemented in a sustainable manner. Ultimately, these programs end up encouraging water users to adhere to the adopted measures aimed at water saving and conservation.

Goal 1.1	Reduce overall water losses to 30% of the total water demand in 2030 and to 15% of total water demand in 2040.
Goal 1.2	Elaborate a national plan for water saving in agriculture by reducing distribution losses, improving application rates and selecting water saving crops.
Goal 1.3	Establish a sustainable water financing mechanism based on tariffs, taxes and transfers that ensures sustainable cost recovery, at least for operation and maintenance by 2030
Goal 1.4	Elaborate and implement a communication strategy to raise awareness about the water sector challenges in Libya, addressed to all stakeholders, including civil society and policy makers

2. DEVELOPMENT AND MANAGEMENT OF WATER SUPPLY

Water supply in Libya is extremely limited in terms of conventional resources. In the absence of more detailed studies of the non-renewable groundwater potential, orienting Libya's water policy toward the development of additional non-conventional resources is undoubtedly a more rational solution. Therefore, the state should scale-up desalination and wastewater reuse, which can be backed-up with non-renewable groundwater withdrawals when necessary.

2.a Man-made river project

Important investments have already been made to develop the infrastructures related to the Man-made River Project. Even if a switch in the water supply sources might enhance Libya's water security, the Man-made River project will remain a key back-up system. Further hydrogeological studies and periodical monitoring of drawdown and abstractions are important inputs for the re-run of the mathematical models and assessment of the state of the aquifers in order to take strategic decisions about future non-renewable groundwater withdrawals.

2.b Desalination

Desalination of seawater or brackish water is an option that is widely developed in some Mediterranean countries such as Spain, Cyprus, Malta, Greece, and Israel, and in Arab countries such as Saudi Arabia and the United Arab Emirates. Despite the climate similarities shared with some of these countries, Libya is lagging in producing desalinated water. About 21 seawater desalination plants were built prior to 2011, but only 10 were operational in 2011 with a total installed capacity of 390,000 m^3/day and producing a total volume of about 67 Mm^3/year, nearly 10% of the total municipal water supply estimated at nearly 700 Mm^3/year (Appendix 7). Seawater desalination has become much cheaper in recent decades. Today, the average cost of desalinated seawater is less than half of what it was in the last 20 years (Plan Bleu, 2008). Current desalinated seawater cost is less than US$1.5/$m^3$, including investment and operating costs[18]. The cost of desalinated brackish water is noticeably lower than the cost of desalinated seawater. These figures are very sensitive to the cost of electrical energy. Therefore, given oil and gas production rates in Libya and its consequent low cost pf electricity, it is possible for the country to enjoy a very competitive cost of production, and to become a leader in desalination, not only in terms of production capacity but also in cutting-edge technologies. Furthermore, desalination could involve public-private partnerships (PPP), alleviating the financial and technical burden on the national budget and the GDC, respectively.

Factors in favour of the development of seawater desalination projects in Libya

- A high percentage of the population is concentrated in the coastal areas of the country
- The investment and operating costs of seawater desalination projects have decreased significantly in the global market in recent decades
- The large-scale development of seawater desalination projects may be an option to relieve groundwater from excessive abstraction and depletion
- Development of PPP for the promotion of major seawater desalination projects is likely to boost the implementation of these projects across the country.

Figure 29 – Source: African Development Bank Group

2.c Recycled water

Libya has a significant potential for wastewater generated by urban agglomerations that can be invested in agriculture and other possible uses. Significant investments have been made for the development of municipal wastewater collection and treatment infrastructure. The country has built more than 70 sewage treatment plants, with a total capacity of 220 Mm^3/year of treated wastewater suitable for irrigation. However, GCWW data indicate that in 2012, the wastewater collected was 295 Mm^3, of which 50 Mm^3 were collected for treatment and the actually treated volume was 46 Mm^3, and only 15 Mm^3 were used for irrigation. In 2015, only 9 plants were in

18- These are average worldwide figures, as cost varies according to the technological choice, the energy cost, etc.

operation with a total output of 37 Mm^3/year and no reuse of the treated wastewater for agriculture. At present, only 4 plants are operating with an annual output of 16 Mm^3.

2.d Dams

About 18 small and medium-sized dams were built on main wadis, with a total capacity of nearly 375 Mm^3 (Appendix 6). It is planned to reinforce this existing infrastructure by the construction of 20 more small and medium sized dams, with a capacity of nearly 137 Mm^3. Much of these dams will be constructed in the coastal region of Libya to enhance local irrigation development, livestock water supply, and to provide protection against floods.

Goal 2.1	Total rehabilitation of all phases of the MmRP by 2030.
Goal 2.2	Development of additional seawater desalination projects, and rehabilitation and upgrading of the existing plants to increase production to 2,500 Mm3/year in 2040.
Goal 2.3	Promotion of large-scale reuse of treated wastewater for irrigation, in the order of 500 Mm3/year in 2040.
Goal 2.4	Rehabilitation of aging and damaged dams by 2030 and complete the construction of the planned 20 new small and medium-sized dams by 2040.
Goal 2.5	Appropriate regulatory framework and incentives to promote the reuse of treated wastewater to be put in place and operational by 2040.

3. UNIVERSAL ACCESS TO WATER AND SANITATION SERVICES

Before 2011, Libya's access to water and sanitation services witnessed gradual improvements in the percentage of the population connected to public networks. However, this situation has also been affected by the armed conflict. Priority should therefore be given to the rehabilitation of municipal water supply and sanitation infrastructure, to guarantee the accessibility, affordability, availability, and sustainability of the water and sanitation services.

Wastewater treatment should be coupled with water recycling. Therefore, new wastewater treatment plants need to be designed taking into consideration the final reutilization of the treated effluent.

Goal 3.1	Elaboration of a Water and Sanitation Master Plan for the country and for the principal Libyan cities.
Goal 3.2	Rehabilitation of water supply infrastructures to achieve 80% coverage levels in urban areas by 2030.
Goal 3.3	Rehabilitation of sanitation infrastructures to achieve 80% coverage levels in urban areas by 2030.
Goal 3.4	Water supply and sanitation infrastructure expansion to achieve full coverage by 2040.
Goal 3.5	Establishing and equipping a laboratory network for water quality monitoring.

4. PRIVATE SECTOR PARTICIPATION

Libya confronts important challenges to achieve the goals and objectives identified for 2030 and 2040. Not only this will mean the mobilisation of large amounts of funds, which will be challenging in the post-conflict phase, but also the management and development of several projects, which place enormous load on the authorities in charge. In some cases, Public Private Partnerships may be considered as an effective way to improve efficiency, reduce costs, or provide funds for the water and sanitation sector. The involvement of the private sector requires the development of strong capacities within the water authorities, as well as an enabling environment that optimizes the arrangement between private and public sectors.

Goal 4.1	A regulatory framework for Public Private Partnership to manage municipal water supply and sanitation is operational in 2025.
Goal 4.2	Identify and develop a list of projects that can be implemented by a PPP.
Goal 4.3	Strengthen capacity building within the Libyan water authorities.

5. WATER RESOURCES PROTECTION

5.1 Mainstreaming the IWRM approach in all sector policies and strategies

Water resources are finite and interdependent. The allocation and use of water in all the productive sectors, the domestic sector, and the ecosystems should be planned in a coordinated and participatory way. In order to cope with the water scarcity of Libya, as a limiting factor for socio-economic growth, every policy and strategy needs to be sensitive to this situation. This means that all policies and strategies must consider water resources implications, including the two-way relationship between macroeconomic policies and water development, management and use. Water-related decisions should be made at local and basin levels and be along the lines of, or at least do not conflict with the achievement of broader national objectives. This is particularly relevant for the agriculture sector, as this sector alone is responsible for about 80% of water consumption in Libya. Adopting IWRM in agriculture can have a major impact in water security, and conversely, ignoring the limited water availability in favour of greater agricultural productivity is likely to result in a medium-term catastrophe for the country.

5.2 Strenthening transboundary water cooperation

The management of transboundary water resources in Libya, notably the transboundary aquifers of the Nubian Sandstone Aquifer System and the North Western Sahara Aquifer System, has the potential to significantly strengthen water security in Libya and the riparian countries. This relies on effective, sustainable and collaborative transboundary water management and development. The benefits of cooperation in transboundary water are environmental -preservation of water quality and availability-, economic -benefits generated from water uses including energy and agriculture production-, social -referring to drinking water supply and domestic use-, regional integration -as it may be a catalyst for broader regional cooperation- and political -as water cooperation may contribute to peace and conflict resolution.

Strengthening transboundary water cooperation implies the review and adoption of treaties and agreements that reflect the reality of the aquifers and establish accepted and equitable relationship between parties, its expectations and behaviours. To this extent, the accurate knowledge and the good monitoring of the resource is extremely important, including the updating of the data base, the functionality of the monitoring network and the establishment of data exchange protocols.

5.3 Preserving and restoring water bodies

Libya's limited water resources are an extremely valuable asset that needs to be preserved and protected to ensure its sustainable management. This refers mainly to the non-renewable groundwater because of its 'non-renewable' character, but also not neglecting renewable groundwater, wadis and the sea. All the water abstractions need to be controlled and limited by law, strengthening the control system, and implementing sanctions in case of non-compliance. All subsidies regarding water withdrawals need to be re-assessed to prevent uncontrolled water withdrawal or overexploitation. In the same line, polluted water needs to be treated before disposal and its treatment must be paid by the polluter. Innovative and pilot approaches aiming to preserve and improve water bodies, such as the injection of treated water into the aquifers, should be developed to restore aquifer conditions.

Goal 5.1	Integrate the national vision for water security and the IWRM approach in all the sector policies and strategies.
Goal 5.2	Improve transboundary water management by strengthening the knowledge and monitoring of transboundary water bodies and adopting new tailor-made agreements when needed.
Goal 5.3	Identification and development of water restoration techniques for Libyan water bodies.

6. SKILLS DEVELOPMENT AND DATA MANAGEMENT

Libya's armed conflict has caused several displacements and rotations amongst water authorities and related staff. In addition, after several years of conflict, the country needs to modernize and strengthen the staff skills in order to overcome the challenging environment in the medium-term.

A special focus needs to be put on data management. The water sector review has shown that data used in the reports are incomplete or unreliable in some cases. The water sector databases produced by different administrations and agencies reveal inconsistencies and gaps. In addition, these databases are often fragmented and not updated. A good data management system is therefore essential for strategic planning and private sector participation.

The country could draw on the high importance of desalination for the water sector to establish a reference research centre for desalination technologies and efficient energy consumption. The centre could lead the technological advances in the desalination sub-sector.

Goal 6.1	Modernization of the water sector administration and the existing water database system.
Goal 6.2	Modernization of water resources monitoring networks.
Goal 6.3	Identification and implementation of a capacity building plan.
Goal 6.4	Establishment and operation of a Research Centre for Desalination Technologies and Efficient Energy Consumption.

7. STRENGTHENED WATER GOVERNANCE

Institutional and legislative capacities exist but dynamic improvements are needed to cope with the growing challenges. The water sector needs to be oriented towards more effective and efficient collaborative implementation, based on a holistic approach of integrated water resources management with a focus on water demand management.

All the water related institutions prepare and implement their sectoral strategies and action plans. However, there is no clear national water policy or strategy that defines the overall long-term priorities and objectives, associated with a lack of a high-level body with full authority and means to guide and coordinate the water related sectors planning process. Besides, the management of the main water institutions GWRA, MmRA, GDC and GCWW should be assessed in order to improve their performance and to identify existing gaps.

In large public irrigation schemes, water users are not organized and not sufficiently involved in the management process. It is therefore imperative that future efforts focus on improving the performance of the irrigation sector through more active participation of water users. The Libyan authorities have launched recent initiatives with the aim to improve irrigation management by establishing agricultural water users' associations and lease public irrigation schemes to the private sector.

Goal 7.1	Review and amend the water law (3/82).
Goal 7.2	Review the water related organizations (GWA, GDC, GCWW and MmRA) and their responsibilities, with a particular focus on the regulatory function.
Goal 7.3	Implementation of a Work Plan for the main water institutions: GWRA, MmRP, GCWW and GDC.
Goal 7.4	Introduction of a performance-based culture within the main water institutions.

8. CLIMATE CHANGE

The negative impacts of climate change have been demonstrated on global and regional scales. Preliminary studies based on meteorological data of about 50 years indicate that the Libya's climate will also change according to the observed global trends, that is, temperatures will increase, and rainfall will decrease. In addition, the country may be threatened by the occurrence of frequent droughts and flash floods as a result of climate change. So far, no thorough investigations on these impacts were conducted and no practical steps are taken to monitor the impact of climate change on the water sector in Libya, apart from a few academic studies in some areas of the country.

Climate change, coupled with rising water demands, will put additional pressure on Libya's depleting groundwater resources. Current water resources management practices need to be revised to adapt to climate change. and must be replaced by sound practices to be applied alongside the development of non-conventional water resources alternatives and the reorientation of irrigation water policies.

Goal 8.1	Develop and implement a climate change adaptation strategy, capable of responding to future challenges of climate change.
Goal 8.2	Implement an Early Warning System for Drought and Flood management.

VII. APPENDICES

Appendix 1: Organization of the Water Sector and Distribution of Responsibilities

THE GENERAL WATER RESOURCES AUTHORITY (GWRA)

The main government agency dealing with water resources and management has been the General Water Authority (GWA). The GWA was first established as an independent government body on 12 February 1972 according to Law 26,1972. The GWA became a part of the Ministry of Water Resources (MWR) upon its establishment in 2012. The MWR was later reduced to the General Water Resources Authority (GWRA). The mandate of the GWRA can be summarized as follows:

- Developing water resources strategies and policies;
- Prioritizing water abstractions and allocations among the different sectors (agricultural, industrial, and domestic);
- Conducting basic and applied research on water management, water saving techniques, integrated water resources management, and developing alternative water resources;
- Assuring sustainable use of the available water resources;
- Communicating and organizing water uses with all ministries and water stakeholders;
- Drafting water resources guidelines, action plans, laws, and regulations; and
- Supervising the construction of water resources projects.

Clearly, the GWRA's responsibilities are broad and numerous, combining planning, execution, supervision, and regulation. The nature of these responsibilities has overtaxed the GWRA and made it exert strenuous efforts to address all these responsibilities simultaneously. GWRA currently oversees other related institutions, namely GCWW and GDC that were previously affiliated with MWR.

THE MANMADE RIVER PROJECT AUTHORITY

To provide long term solutions to its serious water shortages, Libya constructed the Manmade River Project, the world's largest groundwater conveyance project. Since its inauguration in 1983 as an Inter Basin Water Transfer (IBWT) project, The MmRP has grown to include hundreds of wells, almost 4,000 km of mainly 4-meter diameter of pre-stressed concrete conveyance pipes, pumping stations, enormous storage reservoirs, and complementary monitoring and control structures. Eventually over 6.5 Mm^3 of water will be conveyed daily from wellfields deep in the Sahara Desert to the population centres that are concentrated on the northern coastal strip. The MmRP project has five phases (Figure 17) as follows:

1. Sarir-Sirte, Tazirbu Benghazi System SSTB (completed).
2. Jabal Hasawna-Gefara System (completed).
3. Gurdabiya/Sedada System (completed).
4. The Ghadames/Zwara System (in final stage).
5. Kufra/Tazirbu System (not tendered yet).

The large scale of the project required the formation of a dedicated organization entirely devotedto the operation and management of its various system components, the Man-made River Authority (MmRA). The MmRA also conducts research and continuous monitoring to ensure that the abstraction of water from such deep aquifers is proceeding in accordance with the initial plans and model results.

THE GENERAL COMPANY FOR WATER AND WASTEWATER (GCWW)

The GCWW was re-established in 2008 as a semi-independent body under the supervision and direction of the Ministry of Housing and Utilities (MHU). Its mandate included provision of Libya's cities and towns with potable water and management of the wastewater produced. In this regard, the mandate included the operation and maintenance of all water and sanitation services (WSS) infrastructure including water pipelines, wastewater pipelines, and water and wastewater treatment plants. This mandate was expanded to include the construction of WSS infrastructures and water and wastewater treatment plants. This mandate is shared between the MHU and the GCWW although it is traditionally not within the GCWW's responsibilities.

With the formation of the Ministry of Water Resources, supervision and direction of the GCWW has been transferred from the MHU to the MWR. The GCWW's role as a supplier of supplemental treated effluents has been marginal as the fraction of effluents subject to treatment is very small and often unsuitable for reuse. Moreover, land to be irrigated with treated effluents is no longer available and private farmers prefer using well water to treated effluents.

THE GENERAL DESALINATION COMPANY (GDC)

The GDC was established in 2007. It was charged with the execution of plans and programs in the field of water desalination including construction, operation and maintenance of desalination plants of brackish and seawater. The company's mandate gave it the right to sell the water it produced. Historically, desalination was a Directorate under the Ministry of Electricity. However, upon the formation of the MWR, GDC has been annexed to it. The company's contribution to the national water supplies has been limited to domestic uses with GCWW as its major client.

Other government bodies that are directly or indirectly involved in the management of the water sector include:

THE NATIONAL METEOROLOGICAL CENTER (NMC)

A semi-autonomous organ of the Ministry of Transportation that monitors weather parameters including rainfall, temperature, humidity, wind speed and direction.

THE ENVIRONMENTAL GENERAL AUTHORITY (EGA)

It is a semi-autonomous organ that reports to the Prime Minster office directly. It has the mandate to set the maximum contaminant levels for drinking water and effluent reuse criteria. It also approves projects based on environmental impact assessments, drafts national environmental strategies and action plans, raises awareness of environmental problems, and monitors water quality.

THE MINISTRY OF AGRICULTURE, LIVESTOCK AND MARNE WEALTH

The Ministry oversees agricultural activities at national level including livestock and marine wealth. The Ministry is in charge of implementing agricultural policies. It coordinates with GWRA for future projects and their water needs.

THE JOINT AUTHORITY FOR THE STUDY AND DEVELOPMENT OF THE NUBIAN SANDSTONE AQUIFER SYSTEM (JA-NSAS)

JA-NSAS coordinates the activities of the NSAS to make sure that the transboundary water resources are sustainably managed. Libya hosts the organization's headquarters. JA-NSAS maintains a regional data base and a regional mathematical model that are periodically updated.

THE NORTH-WESTERN SAHARA AQUIFER SYSTEM (NWSAS)

A consultation mechanism was created to coordinates the activities of the NWSAS and make sure that the transboundary water resources are sustainably managed. The three countries (Algeria, Libya, and Tunisia) that share the NWSAS are represented in the consultation mechanism by the following national institutions:

- **Algeria:** Agence Nationale des Ressources Hydrauliques (ANRH)
- **Libya:** General Water Resources Authority (GWRA)
- **Tunisia:** Direction Générale des Ressources en Eau (DGRE)

Appendix 2: Water Laws and Regulations

Law No.3 of 1982 (The Water Code) clearly defines the ownership of water, responsibility of control and management, licensing for drilling, exploitation and use, pollution control, and penalties. Under Law No.3 of 1982, water is a public ownership and can only be exploited by a license which defines the amount and duration of use. A region that witnesses overexploitation resulting in heavy drawdown and deterioration in quality is declared a prohibited zone for further development. The polluter pays principle is clearly stated in the water law along with necessary protective measures.

Complementary legislations that are directly or indirectly related to water conservation are in force. In addition, several Decrees and Decisions by the Council of Ministers and the Ministry of Agriculture and other concerned ministries were issued. Among the laws and regulations of importance are:

- Law No. 142 / 1970 on the tribal lands and wells
- Law No. 8 / 1973 on the prevention of sea pollution by oil.
- Law No. 112 / 1973 on water well drilling
- Law No. 106 / 1976 on the issuance of the health law.
- Law No. 2 /1979 on economic crimes
- Law No. 2 / 1982 on the regulation of the use of ionizing radiation and the prevention of risks.
- Law No. 3 / 1982 on the regulation of the exploitation of water resources.
- Law No. 5 / 1982 on the protection of rangelands and forests.
- Law No. 7 / 1982 on environmental protection (superseded by law no. 15/2003)
- Law No. 1 / 1983 on the creation of the agricultural inspection force
- Law No. 13 / 1984 on special hygiene provisions.
- Law No. 17 / 1985 on the regulation of grazing.
- Law No. 14 / 1989 on the exploitation of marine wealth.
- Law No. 15 / 1989 on the protection of animals and trees.
- Law No. 15 / 1992 on agricultural land protection.
- Law No. 15 / 2003 on the protection and improvement of the environment.

The protection of water resources in general and groundwater aquifers in particular is given unique attention by the Libyan legislation as evident from both the Water Law (No. 3/1982) and the Environmental Protection Law (No. 15/2003).

Appendix 3: Management bodies of the Nubian SandStone Aquifer system and the NorthWestern Sahara aquifer system

THE NUBIAN SANDSTONE AQUIFER SYSTEM (NSAS):

Libya shares the Nubian Sandstone Aquifer System with Egypt, Sudan and Chad. A Joint Authority for the Study and Development (JA-NSAS) of this aquifer system was set up by Libya and Egypt in 1989, then joined at a later stage by Sudan and Chad (2000). Two agreements were signed by the four countries concerning the exchange of updated information. A regional data-base is periodically updated and monitoring of the state of the aquifers with regard to drawdown and rates of abstraction is carried out by local JA-NSAS offices in the riparian countries. Mathematical models were run at the end of regional studies covering the whole basin and scenarios for future expansions in water use in each country were simulated. No threats of interference are in place as per the model predictions; nonetheless, continuous monitoring is underway and can provide early warning against such interferences.

The North-Western Sahara Aquifer System (NWSAS):

Another important shared groundwater resource is the deep aquifers known as the North-Western Sahara Aquifer System (NWSAS). It comprises the Continental Intercalary sandstone aquifer and the shallower Terminal Complex sandstone and limestone aquifers.

The aquifers underlie Libya, Algeria, and Tunisia. Upon an agreement by the riparian countries in 2008, a consultation mechanism was established to manage and share data on the state of the water resources in the NWSAS. The mechanism is in the form of a light management structure hosted in the Sahara and Sahel Observatory (OSS) based in Tunis.

The consultation mechanism includes: (i) A Council of Ministers in charge of water in the three countries, (ii) A permanent Technical Committee composed of the national water authorities (ANRH, GWA and DGRE) and chaired alternately among the countries every two years; (iii) National Committees that can be enlarged to include other national institutions; (iv) National and regional working groups; (v) A Coordination Unit run by Coordinators from each country to promote the implementation of technical activities and meetings and to secure the exchange and dissemination of information.

Appendix 4: Assessment of Total Water Use in Libya (2010-2020)

INTRODUCTION

The latest estimate of the total water use in Libya was conducted by the General Water Authority in 2006, based on field surveys and available relevant data on the agricultural, domestic, and industrial uses. The report summarizes data gathered by GWA branches and technical departments for the year 2005. Major changes have taken place since 2005 that rendered the task of estimating water use by the different sectors more intricate and complex.

In the absence of recent field surveys, certain information sources, although limited, were found particularly useful in filling gaps. Among such sources are the yearly statistical booklets published by the Bureau of Statistics up to the year 2015, the agricultural census of 2007, the Google Earth satellite imageries, the General Electricity Company of Libya (GECOL) annual reports, the report of the committee in charge of the evaluation of water use in the oilfields (2009), reports of the General Company of Water and Wastewater (GCWW), the Man-made River Project, the General Desalination Company (GDC), the Ministry of Agriculture, the General Information Authority, and several other government institutions.

In the following paragraphs, an attempt to assess and quantify the evolution of water use before and after 2011 will be carried out. The time period was divided into two parts: 2000 – 2010 which represents a period of stability and normal growth, and 2011 – 2020 which witnessed some retreat in the growth rates of the major water use components, namely agricultural, domestic, and industrial uses.

AVAILABLE DATA

Two main references are here presented to reflect the estimated water use for the years 1998/99 and 2005.

1. Pallas and Salem (2001): The following estimates were reported in a paper submitted in 1999 for the International Conference on Regional Aquifer Systems in Arid Zones - Managing non - renewable resources and reflects data for 1989/99:

Type of Use	Mm^3
Agricultural[19]	3666
Domestic[20]	605
Industrial	117
Total	4388

2. GWA (2006): Report on the state of water resources in Libya reflecting data for the year 2005.

Type of Use	Mm^3
Agricultural	4088
Domestic[19]	693[20]
Industrial	130[23]
Total	4911

The estimated total irrigated areas in the year 1999 was 313,000 ha and in the year 2005, 350,000 ha, reflecting an annual growth rate of 1.88%.

Part 1: 2000 -2010

The year 2005 is selected as a reference year for the following reasons:

- 2005 is the year with a detailed survey conducted by the General Water Authority for a nationwide assessment of water resources. The figures shown are slightly overestimated in terms of agricultural and industrial uses and can be taken as indicative of the maximum possible uses;
- 2006 is the year of the last population census; and
- The period 2000 – 2010 is stable, with normal growth rates in all sectors.

IRRIGATION USE

Irrigated areas have expanded at low rates with the exception of the southwestern region extending from Sabha to south of Ghodwa, where about 750 centre

19- Including some industrial water demand in the cities
20- Most of the industrial water is used for oil industry (injection, processing, and some domestic use). Not including desalination for industrial use.
21-Including small industries, in the Eastern zone, industrial use is combined with agricultural use.
22-Including 33 Mm3 from desalination and 290 Mm3 from MmRP.
23-For oil production operations in the Kufra – Sarir basin only.

pivot irrigation fields were added for the production of fodder and cereals. In addition, new areas are planted with palm and olive trees in different parts of the country and are all drip irrigated. Assuming that the rate of growth in irrigated areas is around 2% annually and that the initial area in 2005 was 350,000 ha, and adding the newly developed 750 pivots of 50 ha each, the total irrigated area in 2010 would be around 423,000 ha, making the overall annual growth rate for this period 3.86%.

In 2010, irrigated areas in the southern parts of Libya, below latitude 32° N represented about 45 % of the total irrigated area. By applying two application rates: 16,500 m^3/ha in the south and 6,500 m^3/ha in the north (see Appendix 5), the total irrigation use will be approximately 4,653 Mm^3 as compared to 4088 Mm^3 in 2005, which is equivalent to an annual growth rate for this period of around 2.62 %.

DOMESTIC USE

The total population of Libya in 2006 was 5.66 million as per the final results of the 2006 general census report, while that of 2010 is estimated at about 6.2 million. In 2005, it was estimated that the domestic water supply was 693 Mm^3 which includes both the supply through public networks and that of the private sources.

The domestic use for the year 2010 can be estimated on the basis of the population, the average per capita consumption and the actual supply by GCWW. Knowing that the population connected to public networks was around 64%, and the remaining 36%, mostly in rural areas, depend on other sources of supply and presumably consume less water per capita as the "Unaccounted-for Water" is essentially nil. The total domestic water supply by the GCWW in 2010 was 635 Mm^3, which indicates that the per capita consumption is in the order of 438 l/day. The average consumption of the unconnected population can be estimated at 150 l/cap/day or 122 Mm^3/y, making the total domestic use in 2010 around 757 Mm^3, which reflects an annual growth rate of 1.79 %.

INDUSTRIAL USE

In 2009, GWA in collaboration with the National Oil Corporation (NOC) and other relevant government institutions conducted field surveys to precisely determine the quantities of water used for oil production. There are two types of water involved:

- Water mixed with oil during production (accompanying water) and separated on the surface is equal to 730 million barrels/year, 483 million barrels of which are discharged into evaporation ponds and the remaining is reinjected in the oil wells;
- Water produced from source wells and injected in the oil wells to boost production is equal to 471 million barrels/year.

Total net water used (483 + 471) is 954 million barrels or 152 Mm^3. Other uses for different services in the oilfields, such as water supply for the camps and the petrochemical industries are estimated to be in the order of 25 Mm^3 /year.

Apart from oil production, there are 864 large industrial establishments of more than 10 employees in 2006 with 53,758 employees and 16,750 small industries of less than 10 employees with a total of 42,017 employees. Water use by small industries is included either in the domestic or the agricultural uses, reducing the industrial water use to approximately 70 Mm^3/y.

The estimated industrial use for the year 2010 is therefore around 247 Mm^3.

TOTAL USE IN 2010

- The total water use for the year 2010 can be summarized as follows:
- Agricultural use: 4,653 Mm^3 (82.2 %)
- Domestic use: 757 Mm^3 (13.4 %)
- Industrial use: 247 Mm^3 (4.4 %)
- Total use: 5,657 Mm^3, or an annual growth rate of 2.87% from 2005.

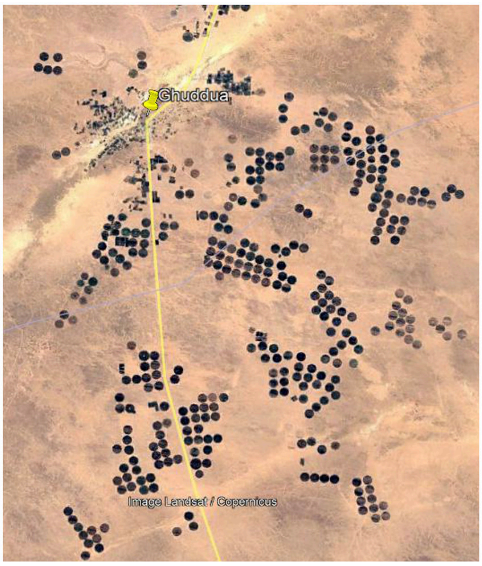
Part 2: 2011 – 2020

Libya has been experiencing an exceptional period of instability since 2011, which has seriously affected all aspects of economic activities and caused major changes in the pattern and trends of development. The period witnessed the displacement of large numbers of Libyans to neighbouring countries, the departure of practically all foreign workers, mainly from the agricultural and construction sectors, and the withdrawal of all foreign companies and diplomatic missions, which led to the closure of thousands of development projects and the deterioration of oil and gas production activities. In general, an overall negative trend has dominated all production sectors since 2011.

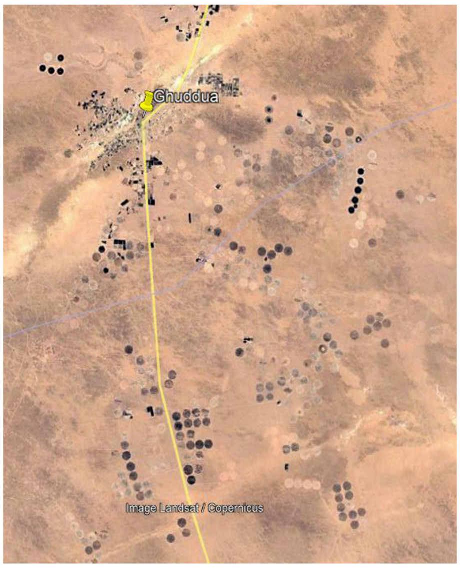
AGRICULTURAL USE

The rapid deterioration of the agricultural sector and other related sectors has contributed to the decrease in water demand. An attempt to quantify such reduction is hereby presented considering all related statistics. State run agricultural projects cover an area of over 40,000 ha, and together with the newly introduced private centre pivot irrigation fields, account for nearly 20% of the total irrigated areas. These projects, along with considerable areas of private farming, have witnessed noticeable contraction due to several uncontrolled factors including vandalism, shortage of power supply, security issues, armed conflict, and lack of labour.

Deterioration of irrigated lands



South Ghodwa 2010



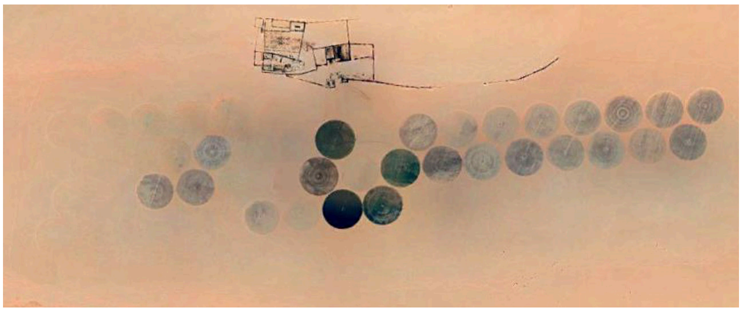
South Ghodwa 2013

Figure 30 and Figure 31- Source : Google maps

Most of these projects are located in the central and southern zones where the annual water application rates average 16,500 m3/ha. Moreover, vast areas of agricultural land near major cities are lost every year due to the spread of urbanization.

Deterioration of irrigated lands

Barjuj 2010



Barjug 2019

Figure 32 and Figure 33 – Source: Google Maps

From the few published data by the Bureau of Statistics, it is possible to formulate a general idea on the level of change in certain indicators that are closely related to the overall performance of the various economic sectors including agriculture. We list below some of these indicators:

- Severe shortage in power generation capacity causing long power cuts in many parts of the country, especially during the summer.
- Drop in oil production from an average 1.7 million barrels/day in 2010 to 0.4 million barrels/day in 2015 (Bureau of Statistics and Census 2015).
- The number of internally displaced people exceeded 400,000 at certain periods (UNSMIL).
- The controlled domestic water supply did not show any increase in the last 10 years but rather a decrease in certain years.
- The number of small and big agriculture contracts with GECOL was 112,901 and 814 respectively for the year 2008 and 117,975 and 924 in the year 2018. This reflects the number of small farms and large state farms and related agricultural activities such as livestock and poultry stations. These figures indicate to a certain extent the growth in the number of agricultural units, as virtually all farmers rely on electrical energy from the national grid to operate their wells and irrigation systems. However, they do not necessarily reflect the net irrigated areas due to the nature and diversity of power use within the farm.

Factors in favour of the development of seawater desalination projects in Libya

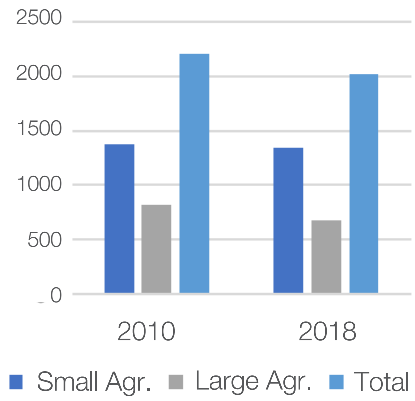


Figure 34 – Source: GECOL

- In fact, power consumption showed a decrease for both categories from 1373.008 GWh for small agriculture in 2010 to 1341.218 GWh in 2018 and from 824.677 GWh in 2010 for large agriculture, to

679.100 GWh in 2018, or a total reduction of about 8%. This ratio can be provisionally adopted as an indicator for the minimum change in agricultural water use during this period.

From the available statistics and satellite imagery, it can be concluded that the irrigated areas in Libya witnessed an estimated 8% to 15% decrease between 2010 and 2020. Using 12% as an average, the total areas under irrigation in 2020 are therefore reduced to around 372,000 ha, but their distribution is different from that of 2010 due to the disappearance of large areas of the public and private large-scale irrigation schemes in the southern part of the country. The new proportions are likely to be in the order of 73% in the north and 27% in the south. Applying the same irrigation application rates, the total agricultural water use for the year 2020 would be in the vicinity of 3,422 Mm³, or a 26.5% decrease from 2010.

DOMESTIC USE

The municipal supply as reported by the GCWW for the years 2010 to 2019 is shown in the table below:

Year	Mm³
2010	635.3
2011	281.8
2012	613.4
2013	568.7
2014	631.0
2015	604.0
2016	631.1
2017	575.2
2018	577.5
2019	427.0

The listed figures may not show a great degree of accuracy for all years, as they are affected by the fluctuation of supply by GDC and MmRP. Nevertheless, they clearly reflect the problems encountered during these years as a result of frequent disruption of power supply, occasional shutdown of the MmRP wellfields, increasing cases of illegal connections, the size of Libyan and foreign population that left the country after 2011, and those who are internally displaced. It should be noted that several cities including the capital Tripoli have encountered intermittent periods of total

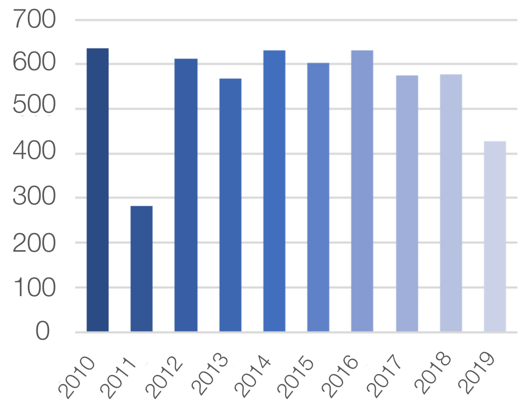


Figure 35 – Source: GCWW

disruption of domestic water supply that lasted for several days and at frequent intervals over the past years. As an example, the total domestic water supply by the General Company for Water and Wastewater declined from 690 Mm3 in the year 2007 to 578 Mm³ in the year 2018, or 16% in 11 years.

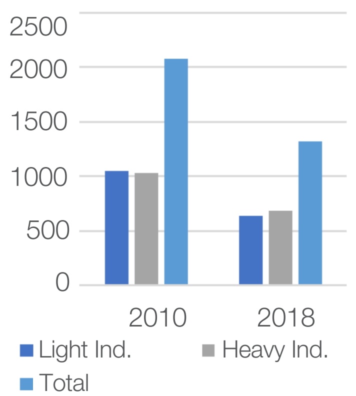


Figure 36 – Source: GECOL

Assuming that the percentage of the connected population is still the same as in 2010, and taking the average supply for the years 2012 - 2018, which equals 600 Mm³ as an acceptable estimate for the year 2020, admitting that the population is 6.8 million (including an estimated one million externally displaced people), it can be assumed that the net population is approximately 5.8 million, of which 64% or 3.7 million are connected to public networks , while the remaining 2.1 million rely on other sources. The per capita use for the connected population will therefore be around 443 l/cap/day. The total use of the unconnected population based on a per capita consumption of 150 l/c/day will be around 114 Mm³. The total domestic water use for the year 2020 is therefore equal to 714 Mm³.

INDUSTRIAL USE

The industrial use for the year 2020 can be estimated on the basis of energy consumption for light and heavy industries, in addition to oil production rates. Both indicators have undergone considerable decrease in recent years, in the order of 36% for the industries and 50% for oil. Accordingly, the total industrial use for the year 2020 can be estimated at 172 Mm³, or 44% decrease from the 2010 values.

TOTAL USE IN 2020

The total water use in Libya for the year 2020 can then be summarized as follows:

- Agricultural use: 3,422 Mm³, 79%
- Domestic use: 715 Mm³, 17%
- Industrial use: 172 Mm³, 4%
- Total use: 4309 Mm³

The total water use in the year 2020 is 24% less than that of 2010 for the following reasons:

- Less irrigated areas as a result of the cessation of major projects run by the state along with hundreds of centre pivot irrigation systems in southern Libya;
- Loss of extensive agricultural areas to urbanization;
- The displacement of one million out of the country;
- The average oil production fell to about half;
- A significant decrease in industrial activities.

EVOLUTION OF WATER USE

The following table and chart summarize the evolution of water use estimates for the last 20 years. Values for the year 2015 were extrapolated.

	Agricultural	Domestic	Industrial	Total
1989/99	3666	605	117	4388
2005	4088	693	130	4911
2010	4653	757	247	5657
2015	4038	736	209	4983
2010	3422	715	172	4309

Evolution of Water Use

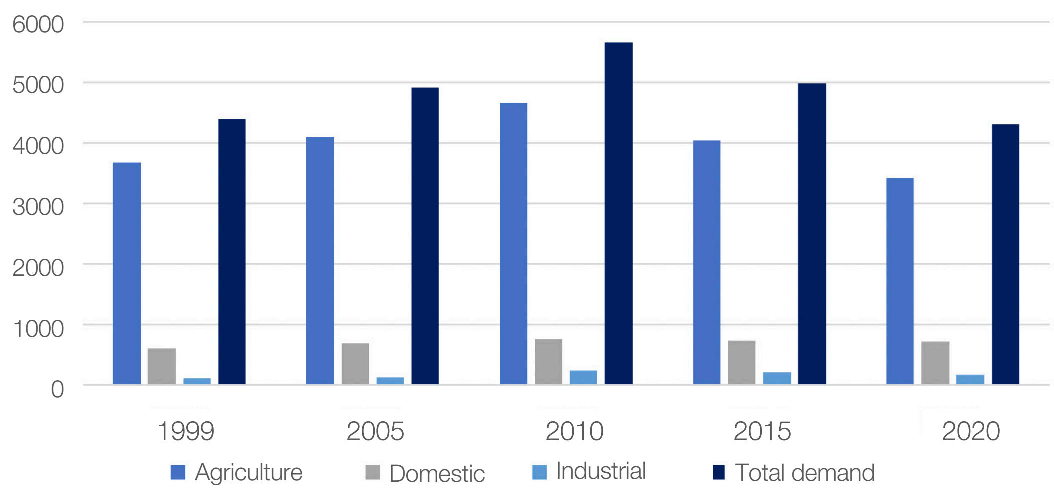


Figure 37 – Source: African Development Bank Group

Appendix 5 - Irrigation Application Rates

Several studies and surveys were conducted to determine the irrigation application rates in different regions of Libya. Application rates depend on many factors including season, type of crop, irrigation system, type of farming (private or state project), location, and climate. The main irrigation zones are hereby presented.

GEFARA PLAIN

1. R. Menuel (79). Estimation of Water Application for Agriculture in the Gefara Plain During Years 1973 and 1978. Gefara Plain Water Management Project. FAO.

The study concluded that the average rate for 1973 was 5799 m^3/ha and the year 1978/79, 5119 m^3/ha

2. Mott MacDonald (1994). General Plan for the Utilization of the Great Man-Made River Waters – Phase II. Final Water Management Plan. Volume 3: Annexes A & B.

The consultant defined the irrigated areas in the Gefara plain using satellite imageries for three periods in 1992 as follows:

- January 1992: 114,960 ha
- April 1992: 74,760 ha
- August 1992: 61,920 ha
- Net irrigated area 1992: 126,300 ha

And concluded that the irrigated crops in 1992 were: perennial 49,800 ha, winter 65,500 ha, and summer 11,800 ha.

The irrigation applications were then developed based on the predominant irrigated crops and typical cropping patterns. Based on Menuel's data (1978), the gross application for the three crop types and their weighted averages (based on relative cropped areas) were as follows:

Crop Type	Crop	Gross irrigation application (m^3/ha/y)
Perennial	Orange Alfalfa	6,000 12,000
	Area weighted average	7,081
Winter annual	Winter truck Winter fodder/cereal Miscellaneous	3,000 1,000 3,000
	Area weighted average	1,328
Summer annual	Summer truck Summer fodder	7000 6000
	Area weighted average	6,651

The consultant assumed that actual application is 70% of the theoretical crop water requirement, the above figures were then adjusted, and the weighted average applications derived from Menuel's figures have been increased as follows:

- Perennial: 10,000 m^3/ha/y
- Winter annual: 2,225 m^3/ha/y
- Summer annual: 13,400 m^3/ha/y

Accordingly, the groundwater abstraction for the season 1991/92 is 802 Mm^3, or an average annual application rate of 6350 m^3/ha

3. Pallas, P. and Salem, O. 2001. Water Resources Utilization and Management of the Socialist People Arab Jamahiriya. Proceedings of the International Conference on Regional Aquifer Systems in Arid Zones - Managing non - renewable resources. Tripoli, Libya, 20 -24 Nov. 1999. IHP-V Technical Documents in Hydrology, UNESCO, Paris, pp 147 – 172.

This paper, based on previous surveys, concluded that the agricultural water use in the Gefara plain was 900 Mm^3 for a total area of 142,000 ha (private farming), making the average application rate at 6338 m^3/ha.

For the Khoms – Misrata coastal area, the application rates for the private farms were 10,000 m^3/ha and 14,693 m^3/ha for the agricultural projects.

JABAL AKHDAR

Pallas and Salem (2001) indicated that all irrigated areas in the Jabal Akhdar are private, with a total area of 24,000 ha. The total water use for irrigation was 196 Mm^3 making the application rate at 8,167 m^3/ha.

It is therefore appropriate to use an application rate of 6500 m^3/ha as representative for the northern irrigation zones.

MURZUQ BASIN

1. Illy, Paul 1984. Groundwater Development Control of Murzuq Basin. Land and Water Investigations Project. FAO.

The study covered the state-run irrigation projects in the different sub-zones of the Murzuq basin during the season 1983/84. Extraction in irrigation projects was based on readings from water meters and in some cases on time counters recording the duration of pumping from wells. Other data is based on information on water requirements, number of wells, pumping duration, pump capacity or well discharge. Some of the projects are not fully operating or not yet started. Planned application rates are higher than the ones currently calculated based on actual areas and extractions.

A summary of results is presented in the table below.

Irrigation Zone	No. of projects	Area actually irrigated (ha)	Total extraction (Mm^3/y)	Application rate (m^3/ha/y)
Murzuq	12	5,165	83.5	16,166
Wadi Ajal - Ghat	9	3,482	63.17	18,141
Sabha	4	954	19.2	20,125
Wadi Shati	4	5,169	68.3	13.213
Total Murzuq Basin	29	14,770	234.17	15,854

2. Idrotecneco (1982). Hydrogeological Study of Wadi Ash Shati, Al Jufrah and Jabal Fezzan Area. General Report. Department of Water and Soil. Tripoli.

According to the results of the agronomic survey conducted by the consultant, the average annual water consumption per hectare of private farms in Wadi Shati was 14000 m^3. However, the reported average annual consumption of Brak – Ashkeda and Umm Al Jadawil projects was estimated by Italconsult in 1978 to be 25,000 m^3/ha. Idrotecneco used an average 16,711 m^3/ha for future demand in agricultural projects in Wadi Shati.

Year	Area	Cultivated Land (ha)	Exploitation (Mm³/y)	Application Rate (m³/ha)
1978	Wadi Shati	2710	38.0	14022

3. Pallas and Salem (2001) reported application rates for both private and state projects as follows:

Zone	Irrigated Area (ha)		Water Use (Mm³)		Application Rate (m³/ha)	
	Private	Projects	Private	Projects	Private	Projects
Murzuq Basin	85,625	18,311	1,425	248	16,642	13,543
Kufra – Sarir[24]	8,700	18,800	148	204	17,011	10,851

At present, most of the irrigated areas are private, therefore it is appropriate to adopt an application rate of 16,500 m3/ha for the southern zones.

24- including Tazirbu and Jalu

Appendix 6: Existing dam Reservoirs

	Dam Name	Location	Storage Capacity	Average Yearly Storage (Mm³)
1	Megenin	Bin Ghashir	58.00	10
2	Caam	Zliten	111.00	13
3	Ghan	Gharian	30.00	11
4	Zaret	Rabta	8.60	4.5
5	Lebda	Khoms	5.20	3.4
6	Gattara	Benghazi	120.00	12
7	Gattara (secondary)	Benghazi	1.50	0.500
8	Murgus	Ras El Hilal	0.044	0.150
9	Ben Jawad	Ben Jawad	0.340	0.340
10	Zaza	Aguryia	2.00	0.800
11	Derna	Derna	1.15	1.0
12	Abu Mansur	Derna	23.70	2.0
13	Tabrit	Zliten	1.60	0.500
14	Dakar	Zliten	1.60	0.500
15	Jaref	Sirte	2.40	0.300
16	Zhawyia	Sirte	2.20	0.700
17	Azzeid	Sirte	2.60	0.500
18	Wishka	Jufra	3.65	0.200
Total			375.584	61.39

Appendix 7: Seawater desalination plants:

7 seawater desalination plants are currently operational, producing about 32.2 Mm^3/year 2019:

Location	Desalination type	Design capacity m^3/d	Number of units	Operation status
Tubruq	MED-TVC	40,000	3	Working
Bomba	MSF	30,000	3	Not Working
Derna	MED-TVC	40,000	2	Working
Sussa	MED-TVC	10,000	1	Not Working
Sussa ext.	MED-TVC	40,000	2	Working
Abou traba	MED-TVC	40,000	3	Working
Zliten	MSF	30,000	3	Partly Working
Zawia	MED-TVC	80,000	4	Working
Zwara	MED-TVC	40,000	3	Working
Zwara ext.	MED-TVC	40,000	-	Incomplete
Total design capacity		390,000		

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