

The Water Resources Management in Libya

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Abstract: One of the major problems that hinder the sustainable development in Libya is the lack of renewable water resources. Rainfall in the country is scarce and infrequent. Over-exploitation of fossil groundwater resources mostly to meet irrigation demands has already affected the northern aquifers. In this paper, it is adapted the Driving Force-Pressure-State-Impact-Response (DPSIR) of the European Environmental Agency (EEA) model. The DPSIR is used as analytical framework for assessing water issues. This allows a comprehensive assessment of the issues through examination of relevant Driving forces and Pressures on the environment, the consequent State of the environment, its Impact, the Responses undertaken. This assessment is preceded by a short description of geographic location, climate and populations.

Key words: Water resources management in Libya

INTRODUCTION

Libya, the fourth largest country in Africa is located in the north of the continent. It lies between latitudes 33°10' N and 18°45' N and longitude 9°58' E and 25°E. It possesses a Mediterranean coastline of approximately 1820 km in length. It is bordered by Egypt to the east, Sudan to the southeast, Chad and Niger to the south and Algeria and Tunisia to the west and northwest respectively (Figure 1). Libya has an area of approximately 1,775,500 km². The country is a cultural and geographic bridge, firstly between Egypt and the Arabian lands to the east and the territory of the Arab west, secondly between the Mediterranean/Europe to the north and the African states to the south. Oil production represents the cornerstone of the country's economic strength. The standard of living is relatively high.

The country occupies a huge area of the African Sahara, with an elevation of between 200 and 300m above sea level. There are several highlands in the northern area, Jabal Nafusah in the north-west and Jabal al-Akhdar in the northeast, with maximum elevations of 980m and 800m respectively. The highest mountain in the country, located in the largely empty southern desert near the Chadian border, is the Tibesti, which rises to 3400m above sea level. A relatively narrow coastal strip and highland steppes immediately south of it are the most productive agricultural regions. Still farther south a pastoral zone of

sparse grassland gives way to the vast Sahara Desert, a barren wasteland of rocky plateaus and sands which supports minimal human habitation and where agriculture is possible only at a few scattered oases. Between the two most productive lowland agricultural zones lies the Gulf of Sidra, where, for a stretch of 500 km, the desert extends northwards as far as the sea.

As a result of its low annual precipitation, the development of agriculture in Libya has made use of groundwater resources. The expanding economy and growing population along the coastal strip are creating increasing pressure on these traditional resources which has resulted in saline intrusion into the coastal aquifers where most domestic, industrial and agricultural activities take place. More than two decades ago, Pallas [1] observed that these coastal aquifers, from which most of the demand for water had been satisfied, could no longer sustain the ever increasing rate of water extraction. Pallas also itemised the sources of the extracted water in the different groundwater systems of the country. In some places in the northern regions, where local over-pumping had drawn from reserves, extracted water exceeded the annual recharge. He considered most of the extracted water in the desert areas was from the reserved storage [1].

To facilitate an understanding of the research context, the Driving Force-Pressure-State-Impact-Response (DPSIR) of the European Environmental Agency (EEA) [2] can be adopted (Figure 2).



Fig. 1: Map of Libya.

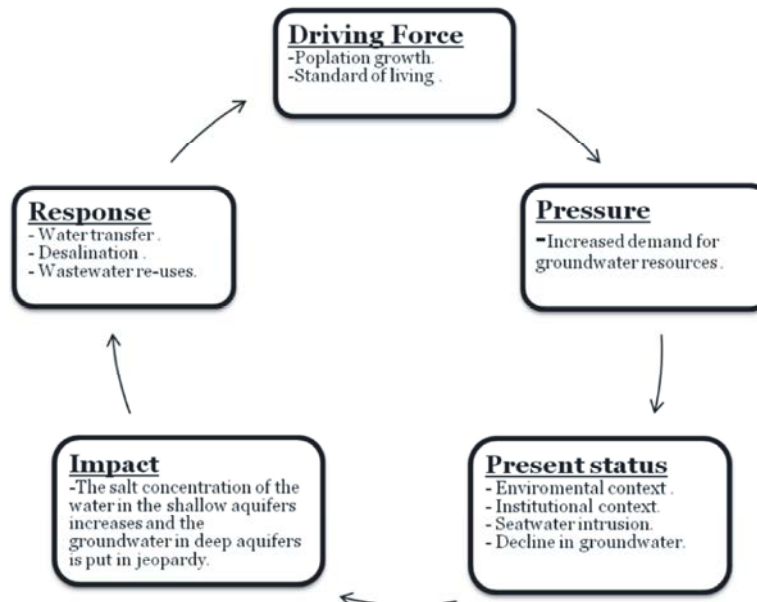


Fig. 2: Conceptual Frameworks (adapted from [2]).

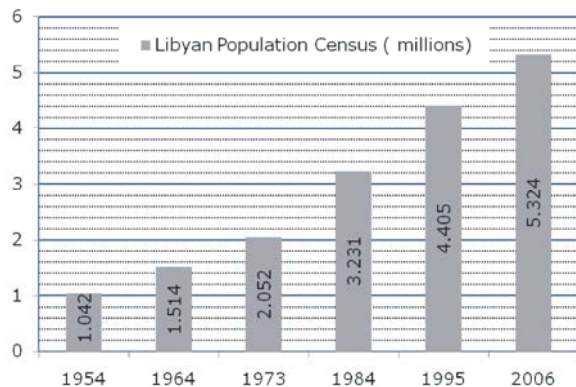


Fig. 3: Evolution of the Libyan population between 1954 and 2006.

Driving Force: In Libya, the needs and demands of a rapidly increasing population have been the principal driving force in the allocation of water resources to various kinds of users, with food availability as the primary aim. Population pressure and increased competition among different land users have highlighted the need for more effective water resources planning and policies. Rational and sustainable water use is an issue of great concern to the Libyan authorities and to water users interested in preserving water resources for the benefit of present and future generations.

Population growth is the primary factor driving increases in the demand for food and agricultural products. The Libyan population increased from 1.042 million in 1954 to 5.324 million in 2006 as illustrated in (Figure 3), which shows the growth rate in approximately ten-year intervals varying between 1.74% and 3.82%. The average population density in 2006 was 3.03 persons per sq km. However; more than 80% of the population is settled in the narrow coastal strip while the rest live in scattered oases across the southern part of the country.

Libya emerged from the protection of the United Nations (UN) in 1951 as one of the world's poorest nations with little potential for improvement. It had a population of just over one million, most of who lived in the relatively fertile coastal strip. The remainder of the people were scattered in fertile oases sparsely distributed over the arid Sahara.

Although oil elsewhere was abundant and prices low during the first decade of Libyan independence, the potential existence of large oil deposits, coupled with Libya's proximity to Europe, led companies to seek exploration and production concessions. In response, Libya, introduced a system of competitive trading in 1955 for small-scale exploration and production on favourable

terms. These innovative concessions stipulated that exploration programmes had to be completed by certain dates and that large parts of the acreage had to be relinquished to the government at regular intervals. This led companies to explore actively within a fixed and relatively short period. By the time the Suez Canal was closed by the Middle East war in 1967, Libya was exporting 1.7 million barrels of crude oil per day. This rate rose to 3.7 million barrels per day in 1970, which proved to be the high point of Libyan oil production. The impetus behind this dramatic growth was that, unlike Iraq and Saudi Arabia, which had to export via pipelines crossing potentially hostile territory, Libya could export directly to Europe from its newly established oil fields.

In this way, Libya became a significant source of crude oil. Since then the standard of living has improved remarkably and the national economy has made tremendous strides. Socio-economic projects have been instituted in various fields relating to agricultural and industrial production and to energy and roads. The purpose of these projects is to help create an economy based on sectors other than petroleum, which is a diminishing and unstable resource. This dramatic change in the Libyan standard of living has been a major factor in its high population growth and is regarded as a secondary factor driving increases in the demand for suitable services and a better life style.

Pressure: The increasing pressure on water resources has led to their degradation. The intensive use of groundwater resources has brought about a decline in underground water reserves, resulting in sea-water intrusion. The introduction of sea-water into the coastal aquifers has led to the salinisation of their lower parts. Faced with these problems, the authorities need to formulate and implement appropriate policies (responses) to reduce the pressure and to influence the present situation.

Present Status: It is vital to identify the present status of the water resources. This includes the development of these resources within both the environmental and the institutional context. Very important questions have to be examined below, the status of the soil, climate conditions and the water resources.

Environmental Context

Soil Resources: Extensive soil studies have been conducted in Libya over the last four decades. The focus of attentions has been mainly on the northern part of the

country and on small scattered areas in the southern desert. Most of these investigations have been conducted for the purpose of agricultural development. For example, Russian soil experts have surveyed huge areas totalling 3.5 million hectares in western and eastern regions where the average annual precipitation exceeds 200 mm. They also surveyed another 0.5 million hectares elsewhere at locations that receive an average rainfall within the range of 50-150 mm.

The gray-brown soils of the Gefarah plain and the Nafusah plateau are fertile, although they have become saline due to excessive irrigation. In the east, the soils lying between the Jabal al-Akhdar and the sea are light and fertile. Rich soils are only found in the coastal valleys. The rest of the country is covered by wind-eroded sand or stony desert. The soils in these areas are poorly developed and contain very little organic material. On the margins of the Sahara, the soils are seriously depleted as a result of cultivation and overgrazing.

Climate: Due to the lack of natural barriers, the climate conditions in Libya are influenced by the Mediterranean Sea to the north and the Sahara desert to the south, resulting in a gradual transition from one kind of climate to another. The following broad climate zones can be distinguished:

- In the coastal lowlands, where 80 percent of the population lives, the climate is Mediterranean, with warm summers and mild winters.
- The Jabal Nafusah and Jabal al-Akhdar highlands experience a plateau climate, with higher rainfall levels and low winter temperatures.

- Moving southwards to the interior, semi-desert and desert climate conditions prevail, with torrid temperatures and large daily thermal amplitudes. Rain is rare, irregular and diminishes progressively towards zero in the south.

The average annual rainfall varies from region to region according to geographic location and topography. Generally, the rainfall in the northern part of the country ranges between 100 and 500mm/year. The south receives as little as 10mm and some areas such as al-Kufrah and Murzaq are rainless. The temperatures vary in all climatic divisions. In summer, they can exceed 40°C, but in winter they can fall below zero. On rare occasions, snow has been witnessed on the northern hills and mountains. Inland, the temperature rises as the rainfall and humidity decrease. Rainfall occurs during the winter months (October to March), but occasionally also in April and May. December and January are the wettest months. The total amount of rainfall varies from one place to another. It reaches 350 mm/year in Jabal Nafusah and the western coast and sometimes exceeds 500mm/year on Jabal al-Akhdar. It decreases rapidly with distance inland to 10mm/year in the southern half of the country [1, 3-5].

The prevailing winds are north-easterly in the northwest of Libya and north-westerly in the rest of the country. In spring and autumn, strong southerly winds known locally as “Ghibli” blow from the desert, filling the air with sand and dust. These strong winds are a major erosion factor in the desert, transporting sand from one place to another.

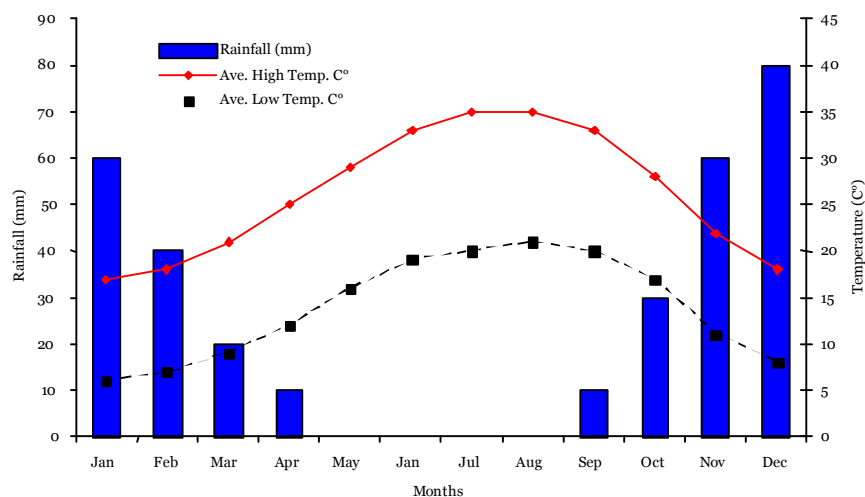


Fig. 4: Average Annual Rainfall and Temperature in Tripoli.

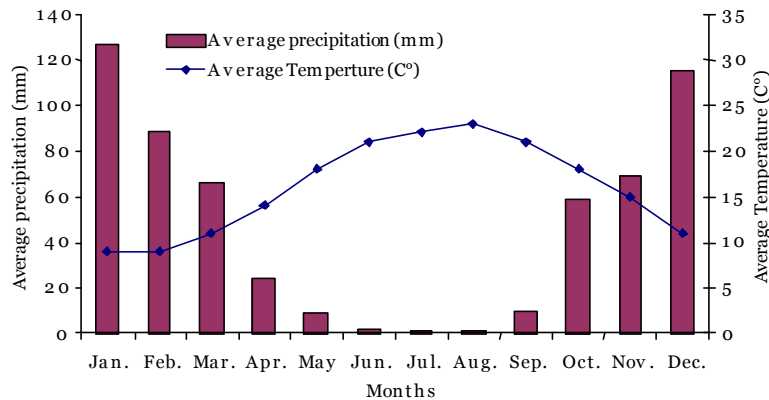


Fig. 5: Average Annual Rainfall and Temperature in Jabal al-Akhdar (Shahaat).

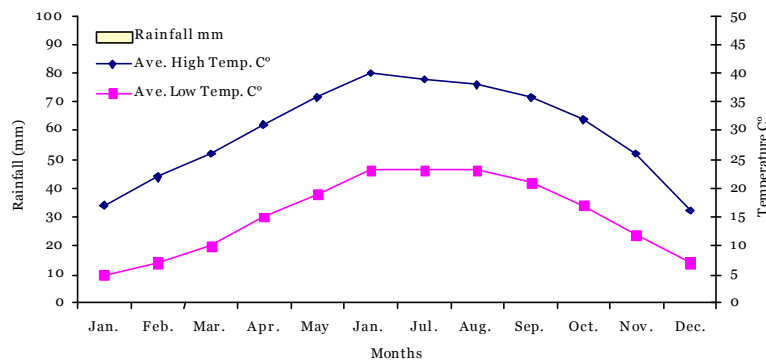


Fig. 6: Average Annual Rainfall and Temperature in Murzaq (Sabha).

Water Resources: Several hydro-geological studies have been carried out in Libya alongside the oil and gas explorations. Most of these studies aimed to investigate the availability of groundwater resources and the potential for their development in various parts of the country. It has been discovered that, while most of the population and consequently of water demand are concentrated within a narrow strip along the Mediterranean coast, most of the groundwater potential is located to the south in the desert area [1].

Institutional Context

Political Institutions: The overall responsibility for all development and all funding allocations rests with the Libyan Minister's Cabinet (MC). The MC implements the decisions and recommendations of the National Council (NC). The Agricultural Ministry (AM) is responsible for agricultural development.

In late 1990s as a means of reform and decentralisation, the country was divided into several local authorities. These local authorities were supposed to be the cornerstone of so called new reform. Each local authority has overall responsibility for planning in its area. However, its plans often conflict with those from the

Central Authority. As a result, the work of the General Water Authority (GWA) faces obstacles at local level.

The GWA has responsibility for water utilisation and for the assessment and monitoring of all water resources in Libya, whilst the Agricultural Ministry (AM) is responsible for the development of irrigated agriculture and the implementation of major projects. The Man-made River Project Implementation Authority (MRP) was created in October 1983 and invested with the responsibility of extracting water from the aquifers in the south and transporting it by the most economical and practical means for use in the Libyan coastal belt. Figure (7) shows the different relations between the decision-making institutions.

As the huge amount of water extracted and transported by MRP was intended to be used for municipal and industrial purposes as well as, principally, agricultural purposes, it became necessary to establish another authority to manage its distribution among the different sectors. This authority is mainly concerned with the preparation of technical specifications for the agricultural projects which are to be implemented. It is also responsible for the technical and administrative realisation of the whole project.

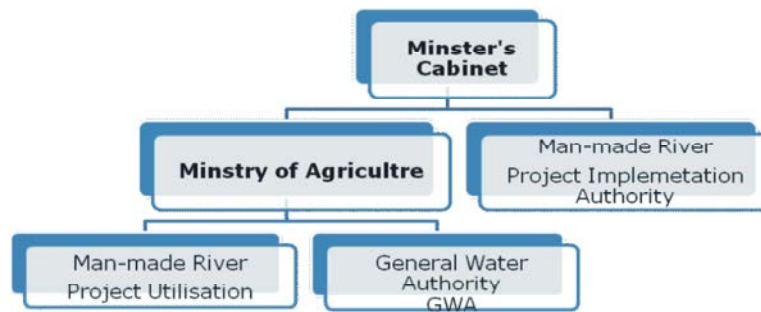


Fig. 7: Institutional environments.

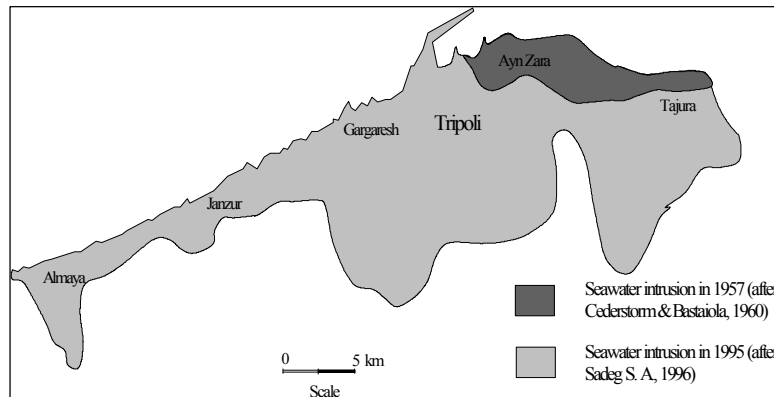


Fig. 8: Seawater intrusions in the North western Area of Libya (adapted from [8]).

Social-Political Considerations: In recent years food security has been given priority in national policy. The aim is to attain self-sufficiency for those agricultural products which are the mainstays of the diet of most Libyans, thus decreasing food import requirements for food imports in 1990 [6].

Recent developments in agriculture have been directed towards increasing the total production of cereals. The increase in agricultural production has been made possible by an increase in the extent of irrigated areas. However, this increase can also be associated with a decline in groundwater levels, particularly in some parts of the northwest of Libya.

Seawater Intrusions: The lack of surface water resources, the limited annual rainfall and escalating water demands in Libya during the past few decades have led to pumping and over-exploitation of the local groundwater aquifers. In the coastal areas, the size and annual recharge rates of these aquifers are limited. In several locations, they have been exposed to unacceptable levels of piezometric decline “and sea-water intrusions”.

The inflow from the sea induced a strong deterioration of the water quality in the Tripoli area and several kilometres inland from it due to seawater intrusion into the shallow aquifer (Figure 8), [7]. The growing

salinity of the groundwater along the coast has made the water supply to the villages located around the city of Tripoli more and more problematic. Pallas observes that the start-up of water supply from the GMRP Phase II on September 1, 1996 spared the Tripoli area from the worst effect of this situation. The map below (Figure 8) shows the increased extension of the seawater intrusion from 1957 to 1996.

Decline in Groundwater Level: In north western Libya, there was a dramatic decline in water levels in both shallow and deep aquifers from 1972 to 1999. The shallow aquifer which was the origin of the agricultural development of the Gefarah Plain is now almost depleted in the area south of Tripoli; between Bin Gashir, Swani and Al-aziziyah see (Figure 9). Moreover, this decline in the water level has resulted in a severe seawater intrusion along the coast from Zanzur to Tajurah, where the groundwater is now unusable. After the disappearance of the shallow aquifer, the farmers started deepening their wells and the deep aquifer has now also been strongly affected by the decline in water level, which exceeds 50 m in the most affected areas [7].

Pallas also concluded that there are water level declines in other locations along the coast due to the overexploitation of groundwater [56]. The graph below

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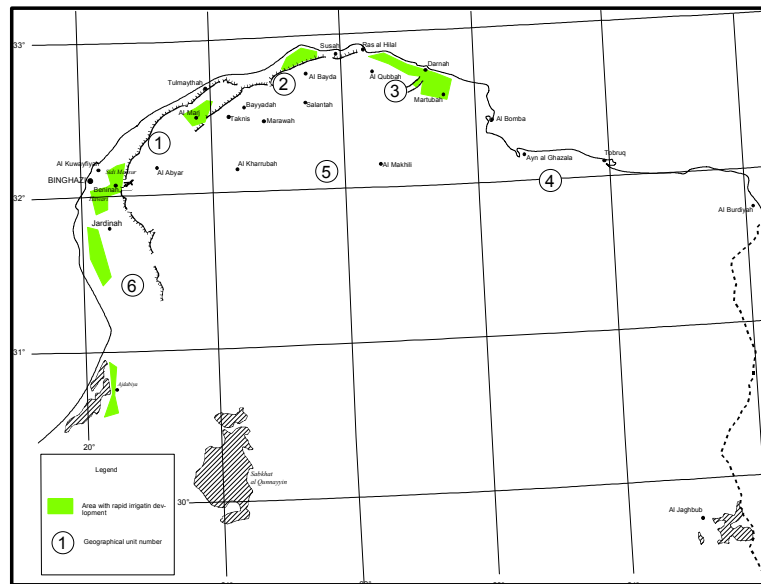


Fig. 10: Agricultural activities locations in Jabal al- Akhdar (adapted from [8]).

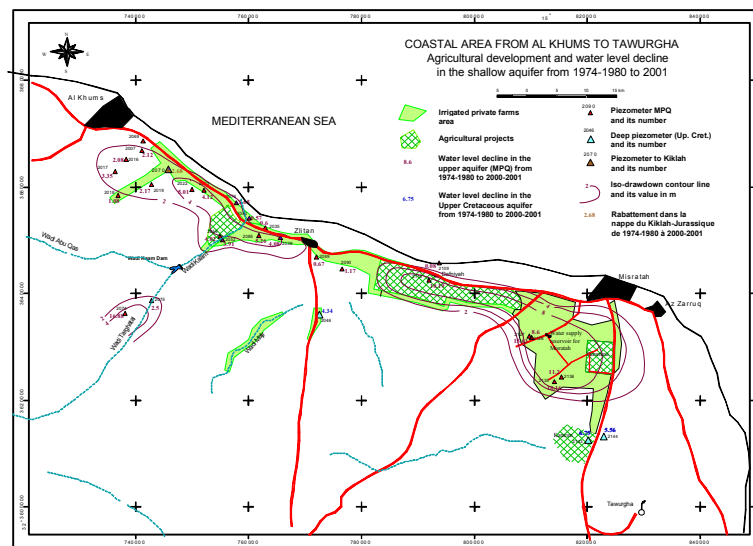


Fig. 11: Agricultural development in the coastal area of Nafusah/al-Hamada (adapted from [8]).

however, the flow into the Aral Sea diminished. By now, the Aral Sea has lost large parts of its surface area and continues to shrink [9]. Besides the disappearance of many fish species, causing many fishermen to lose their jobs, winds have picked up huge amount of salt from the dry sea bed and dumped it on the surrounding farmland, harming and killing crops.

The Aral Sea tragedy offers the most striking modern example of the interconnections between the environment and the economy. Moreover, there is a clear parallel with the present situation in Libya. As the mining of the groundwater continues in the coastal areas, the salt

concentration of water in the shallow aquifers increases and the groundwater in deep aquifers is put in jeopardy. The cost and the risk of ignoring this spread of saltwater intrusion are rising.

Response: As noted in previous sections, there is population growth and consequently a growing demand for water. Libya relies heavily on groundwater to satisfy its ever-increasing water needs, with minor contribution from surface water [5]. As described in the water resources section, a serious water deficit in the balance between supply and demand for water has existed for

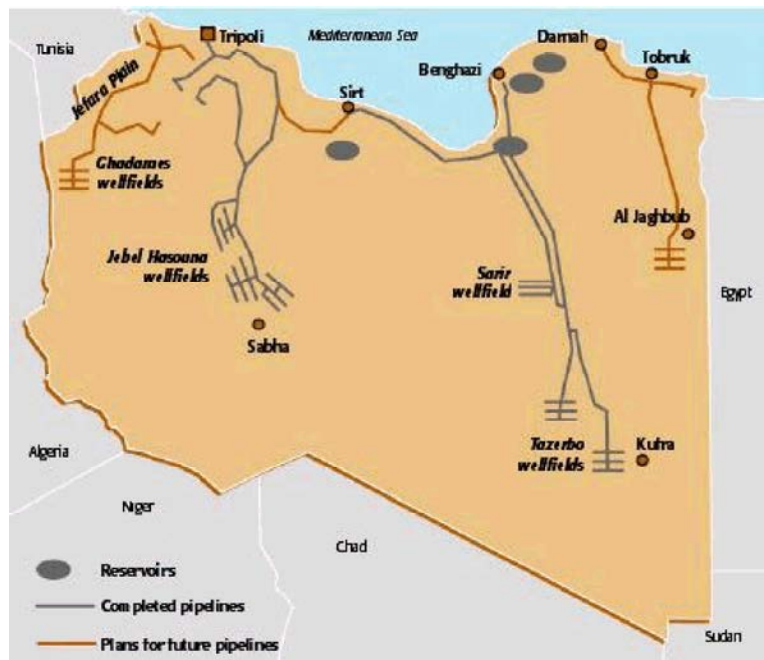


Fig. 12: Great Man-Made River Project (adapted from [11]).

several years. This deficit will undoubtedly increase in the future as the population continues to grow and consequently, water requirements for domestic, industrial and agricultural purposes also increase [10]. This situation is exerting pressure on the decision-makers to formulate effective policies to face these challenges. The government can select from three main options: water transfer, desalination or wastewater recycling.

Transfer of Water: The expanding economy and the growing population along the fertile coastal strip of the country are creating an increasing demand for water for irrigation, industry and domestic use. At the same time, conventional water resources are increasingly at risk due to intensive use, which is resulting in saline intrusion in the coastal aquifers. To provide the people of Libya, most of whom live along the Mediterranean coast; the government has planned, designed and implemented the world's largest and most expensive groundwater pumping and conveyance project. It is called the *Man-made River Project* (MRP). Construction began in the mid-1980s and still continues [10]. It had been known for some time that groundwater existed under the sands of the Libyan Desert. Explorations for oil during the 1960s further defined the extent of these groundwater aquifers. Without foreign or international support (but rather with funds obtained from taxes on gasoline, tobacco and foreign travel), Libya began to design and install the hydraulic

infrastructure needed to withdraw and transport this groundwater from its sources to various demand sites along Mediterranean coast (Figure 12).

Desalination: Groundwater quality is deteriorating in the coastal strip where the majority of the population lives and where most of the country's industrial plants are located [5]. There is thus pressing need for plans and policies to counter this problem. With the country's long Mediterranean coastline, desalination presents an obvious potential.

Desalination technologies have been used in Libya since the early 1960s, mainly by oil companies in water shortage locations [10]. Since then the Libyan government has constructed more than 400 desalination plants with a total installed capacity of over 0.65 Mm³ per day. Desalinated water is used mainly for municipal and industrial purposes [10].

The application of desalination technologies has met with both successes and problems. These latter have resulted in the actual capacities being only a small fraction of what was anticipated [12].

Abufayed and Committee [5] summarise the major problems associated with the desalination process: contracting and technical problems, as well as operational and maintenance problems. The technical contracting problems occurred due to limited experience of local constraints and factors in the early 1960s and 1970s,

which meant that these were given little consideration in design criteria, process technology, operation and maintenance systems. The operational and maintenance problems were caused by lack of experienced personnel, spare parts and materials [10].

Alghraiani compares the cost of water transfer and desalination in North Africa, with particular reference to Libya. He concludes that since the 1970s and 1980s seawater desalination has become cheaper than transferred groundwater from the Saharan and Sub-Saharan aquifers, at least in the case of the Libyan MRP. He further concludes that the Libyan authorities should reconsider their position on the completion of the remaining stages of the MRP [4].

MRP Authority has responded to Alghraiani's concerns by pointing out that economics was the sole criterion of his comparison, with other factors such as environmental impact and water use. It further notes, by citing low operating and capacities in comparison with full operation potential, that the Libyan experience with seawater desalination is not encouraging.

In conclusion, most of the studies of desalination in Libya agree that desalination is a bright prospect and can play an important role in securing the country's water supply. However, there is a disagreement about whether desalination can be considered the primary source in the short term [10].

Wastewater Recycling: In the last four decades, Libya has witnessed a rapid increase in its population coupled with relatively dense urbanisation in some areas along the coast. This has necessitated the establishment of infrastructure such as roads, water pipeline networks and wastewater treatment plants in urban and rural areas. In the 1970s and 1980s there were two main reasons for giving priority to domestic wastewater treatment : (1) to protect the environment by limiting the amount of polluted water and its negative impact on public health and economic resources and (2) to look for a way to develop extra non-conventional water resources. Even if recycled water is not to be used as drinking water, there are some beneficial uses to which recycled water can be put, many of which substitute water of a potable standard and, when combined, make up a significant volume of water [13].

Conclusions and Recommendations: Population growth is a major driving force behind water extraction in Libya. The demand for water is rapidly increasing. The responses from the government have been to transfer

the water from the desert aquifers to the coastal areas and to consider water desalination as a future alternative. In order for the available water resources to be well used there is an urgent need to avoid water resources deterioration.

- Therefore, there is a great need to improve the system of the water resources management in Libya. This raises questions concerning the future balance of supply and demand and how this balance can be predicted.
- *It is recommended that* the country's water management requires water policy reforms, with emphasis on supply and demand management measures and improved legal institutional provisions.
- It would be worthwhile to conduct an investigation on the actual agricultural policy and the actual institutions that govern the water resources sector. The future study should consider a water resources national council as a tool with political power to set an overall policy in order to shift from the supply-driven approach for water management to a demand-driven approach.
- *It is also recommended a* defined national water resources strategy to improve the living condition of the Libyan people in a sustainable manner. Any future water strategy should be based on a timeframe of preparation period, a short-term goal and a long-term goal.

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