

Status of Water Resources of Al Jabal Al Akhdar Region, North East Libya

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Abstract: The aim of this research is to introduce an overview of the water resources of Al Jabal Al Akhdar (Green Mountain) region, North East Libya, which is an area of unique environment from whole country since it is the wettest part of Libya, largely as a consequence of its proximity to the Mediterranean and its upland character with considerable vegetation cover. Water resources in Al Jabal Al Akhdar area, like other areas of world and Libya, have not been adequately managed and neglected and experience large wastage and abuse. This has led to many negative consequences and water-related problems, such as shortage in the quantity of water and quality degradation. The status of water resources were reviewed base up on the available relevant literatures and inquiries from water institutions, where the main resources were identified and classified and their status were previewed to highlight the major issues regarding resources management and their sustainability.

Key words: Water resources • Libya • Al Jabal Al Akhdar

INTRODUCTION

Since ancient times Al Jabal Al Khdar was the focus of attention of the various ancient civilizations. The great civilizations of the Greeks and Romans had founded and established cities of high planning in terms of social, legal and administrative institutions were compete with the oldest major cities in ancient history. It represented a diverse food basket for the Greek and Romanian cities, where the population activity was mainly in agriculture and grazing as evident from the old infrastructures where the wells, tanks, dams and irrigation canals. In addition to water conservation, soil conservation, olive presses and the ports of export [1].

Al Jabal Al Akhdar (Green Mountain) area is a highland along the northern eastern Libya as shown in Figure (1). It is a crescent-shaped ridge attaining a height of more than 850 m a.s.l. in its central part. The northern flank consists of step-like plateaus bordered by escarpments. The southern flank dips gently towards a depression extending from Ajdabiya to Al Jaghub, which is marked by several large sabkhas. To the east and mostly to the west, a coastal plain is well developed between the foot of the first escarpment and the sea. [2].

There are six main cities in the area; Al Abyar, Al Bayda, Al Marj, Al Qubbah, Darnah and Shahat and about 54 villages, in addition to scattered populations. The census made in the year (2006) by the Libyan National Authority of Documentation and Information indicated that the total population of these populated areas as 530,503 inhabitants. The expected population in 2025 is estimated at 769,487 inhabitants, which considered as a pressure on the water resources of Al Jabal Al Akhdar area [1].

Climate: The climate of Libya varies between the Mediterranean coast and the Sahara desert, in terms of temperature and particularly precipitation Al Jabal Al Akhdar is the wettest part of Libya, largely as a consequence of its proximity to the Mediterranean and its upland character [3]. The distinctive features of this climate are a concentration of rainfall during the cool winter season and a very marked summer drought. The average annual rainfall is 550 mm and the average annual temperature is 16°C. January is the coldest month, while August is the warmest. Rain falls from October until April, with a maximum in December and January. In the winter, air masses over the Mediterranean, an area of



Fig. 1: Location Map

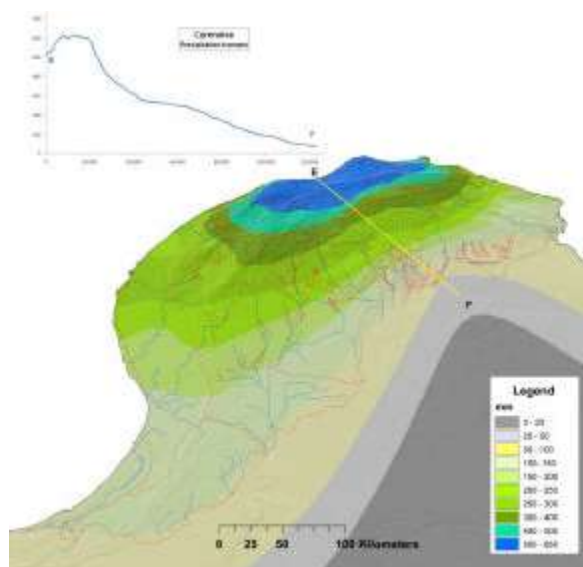


Fig. 2: The spatial distribution of the rainfall of Al Jabal Al Akhdar [5].

convergence between air of Eurasian and Saharan origin, are often rendered unstable by the sea. The result is often cyclonic precipitation, enhanced by orographic uplift, which may be intense [4]. The average rainfall ranges from 200 to 600 mm in the mountainous part of the area. To the south the precipitation decreases sharply and becomes negligible along the southern limits of the area [2] as illustrated in Figure (2) that shows the spatial distribution of the rainfall.

Water resources of Al Jabal Al Akhdar

Conventional water resources

Groundwater: Tertiary and upper Cretaceous carbonate rocks are the main constituents of the aquifers in Al Jabal Al Akhdar area, while perched aquifers generally occur locally in Quaternary deposits. The lithological natures of those aquifers are predominately made of chalky and calcarenitic limestone, in addition to karst processes playing the main role in the presence of water bodies in the whole area, in which they are expressed by development of macrokarstic features. Groundwater flow is mainly related to a system of micro fissures and micro pores. The recharge of the aquifers is due to the direct infiltration of rainfall and to the seepage of runoff water along the wadi beds. The natural outlets of the aquifers are either springs, or in the case of the northern flank, to the sea [6].

The hydrogeological units in the Al Jabal Al Akhdar are illustrated in Figure (3), these are:

- Al Marj-Al Abyar
- Al Qubba Al Bayda-Al Bayyadah.
- Ras al Hilal-Darnah-Martubah.
- Northern boundary of South Al Jabal Al Akhdar.

The boundaries of these units is not defined precisely due to lack of detailed studies, limited exploratory drilling and the lack of integration between the data and information between the different institutions working in the area.

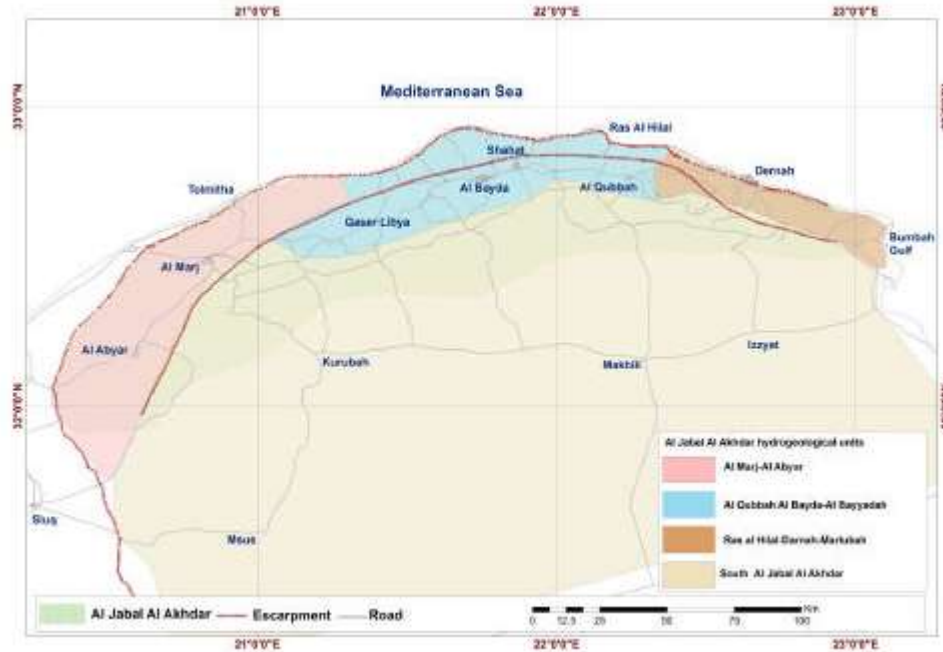


Fig. 3: The spatial extension of Al Jabal Al Akhdar hydrogeological units [8].

Table 1: Main aquifer characteristics of Al Jabal Al Akhdar [7]

Aquifer	Average Depth below the ground level meters	Main constitutes
Quaternary	From 10 to 50	Fluvial deposits
Miocene	From 100 to 150 meters	Marly limestone
Oligocene	From 200 to 250 meters	Calcarenitic limestone
Eocene	From 250 to 350 meters	Nummlitic limestone
Upper cretaceous	From 250 to 350 meters	Dolomitic limestone

Table 2: Famous karst water springs in Al Jabal Al Akhdar

Spring	Discharge liter/sec
Qubah	15
Al Awynat	5
Al Gerylla	3
Dabussiah	80
Stuah	20
Al Qayqab	15
Qlashya	1
Shayb	80
Garm	20
Umm Namous	20
Wadi Dernah Floor	100
Wadi Dernah Tunnel	100
Mqar	10
Balad	50
Ras al Hillal Spring	1.5

According to GWAE [7] those hydrogeological units share common carbonate rocks. Table (1) illustrate the aquifers in the area defined by their geological age. The depth to the aquifers varies due to the geological setting. The Eocene and Upper Cretaceous aquifers has the high potential as water resources in term of quality and quantity and their spatial extension is mainly around the middle parts of Al Jabal Al Akhdar.

More than 100 Karst water springs occur in Al Jabal Al Akhdar area, mostly at geological contacts and vary in discharge as in Table (2) which mostly exists in the northern parts of Al Jabal Al Akhdar. However, some of these springs suffer from pollution problems, as well as the lack of good use and without any monitoring programs in term of water quality and quantity. Moreover, there are submarine springs that flow into the Mediterranean Sea. The amount of discharge from the springs increases during the winter seasons and diminish in the summer, reflecting the recharge of the aquifers feeding them [1].

Figure (4) illustrates the piezometric map of groundwater in Al Jabal Al Akhdar for the year 2006. The map is prepared from different investigations, where there are no periodic monitoring programs for the aquifers water level in the whole area of Al Jabal Al Akhdar since the 1980s.

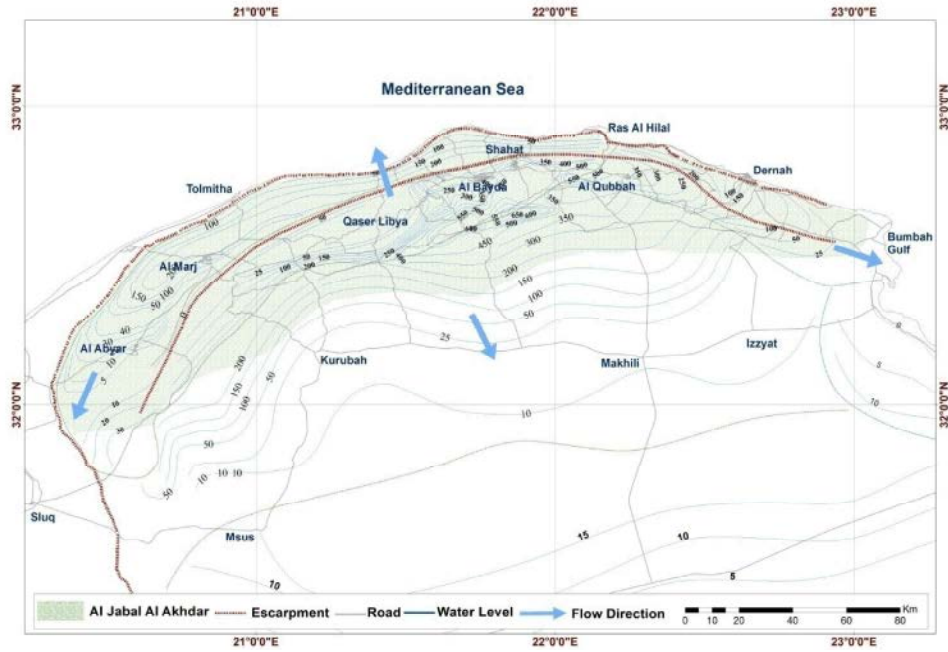


Fig. 4: The Piezometric map of groundwater of Al Jabal Al Akhdar [8].

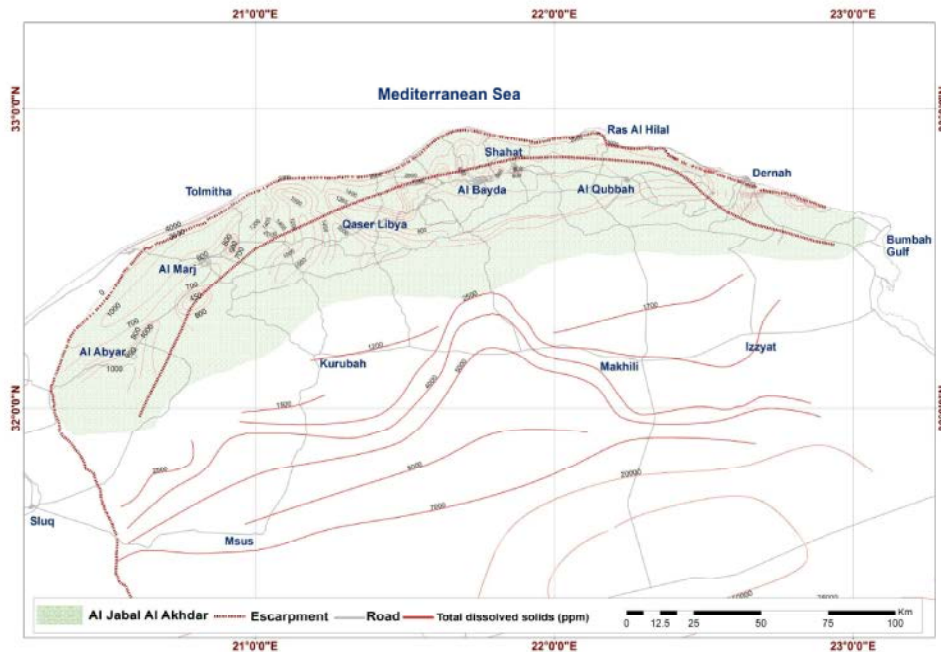


Fig. 5: Water Quality map of Al Jabal Al Akhdar [8]

The map represents only the piezometric contours for the main groundwater bodies. It shows the radial distribution of groundwater flow around the core of Al Jabal Akhdar with very steep hydraulic gradients toward the north, much gentler in the Al Marj-Al Abyar unit. To the south, the water level is gently dips down [1].

The chemical quality of groundwater which expressed by the total dissolved solids (TDS), usually range from 450 ppm to 3000 ppm throughout Al Jabal al Akhdar area, where the quality decreases southward and eastward in relation to the leaching of evaporates, which occur in tertiary deposits, as illustrated in the Figure (5).

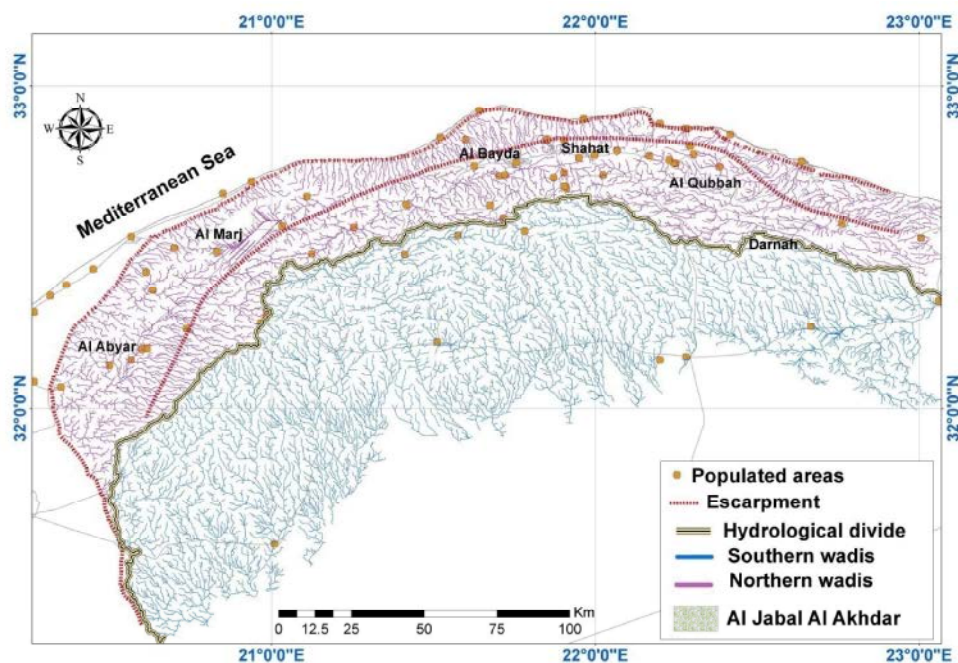


Fig. 6: Wadis map of Al Jabal Al Akhdar [11].

Similar to the water level, there are no periodic monitoring programs for the groundwater quality in the whole area of Al Jabal Al Akhdar. In the northern coastal areas and as result of the increase in groundwater over-exploitation, groundwater quality decreases due to seawater intrusion. The same occurs in urban areas due to dominant pollution by septic tanks [1].

The groundwater is generally of sodium chloride type; however, for water of low TDS, the water is of a calcium bicarbonate type reflecting the nature of the calcium carbonate rocks of the aquifer. The ionic dominance is as follows [9].

TDS < 1000 ppm: $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{2-}$ and $\text{Ca} > \text{Mg} > \text{Na}$

TDS > 1000 ppm: $\text{Cl}^- > \text{HCO}_3^- > \text{SO}_4^{2-}$ and $\text{Na} > \text{Ca} > \text{Mg}$

The groundwater quality of the in Al Jabal Al Akhdar shows verities even in the same aquifer due the complexity of the depositional system of the marine carbonate aquifers, where in some localities some elements like hydrogen sulphide is very common. Also the high values of calcium lead to high hardness of water [1].

Surface Water: Wadi is the Arabic word for ephemeral water courses in the arid regions and they are a vital source of water in most arid and semi-arid countries.

Catastrophic flash floods could occur in wadis [10]. Wadi also refers to the basin area of the drainage system that forms watersheds.

The surface water resources in Al Jabal Al Akhdar area are represented mainly by the wadis, where the hydrographic network reflects the morphological features of both flanks: to the north the valleys are short and deeply cut and reach the sea after a few tens of kilometers and to the south, the valleys are wide and flat and they progressively disappear as valleys and become large spreading zones at the breaking slope of the Al Jabal Al Akhdar [2]. Figure (6) illustrates the layout of the wadis in the area where the hydrological divide in the middle of Al Jabal Al Akhdar represents the boundary of the flow directions for the runoff in the rainy seasons.

The lack of the periodical hydrological measurements led to difficulties in evaluating and estimating the exact amount of surface water resources. However, previous hydrological studies, although for short periods, indicated that around 7, 400,00,000 m³/year of water are available as surface water which can be collected by using different methods of surface water harvesting [6].

Water harvesting has been an indigenous practice in Libya since hundreds of years. It aims at concentrating rainwater through runoff into targets so it can be utilized efficiently in agriculture or other uses. Some of the ancient techniques are still working but maintenance and operation is very costly and some become infeasible.

Table 3: The constructed and proposed Dams in Al Jabal Al Akhdar [12]

Dam name	Location	Total capacity of dam Reservoir(MCM)	Remark
Dernah	Dernah	1	Constructed
Abu Mansur	Dernah	22.3	Constructed
Al Qattarah	Benghazi	12	Constructed
Al Bab	South Benghazi	31.2	Proposed
Al Ahmar	Benghazi	19.5	Proposed
Zaza	Al Aquriah	0.8	Constructed
Al Khalej	Al Bayda	5	Proposed
Al Mallaq	Al Bayda	6	Proposed
Morces	Ras Al hilal	0.15	Proposed
Wadi Quad	El mart	1	Constructed
Total	101.3		



Wadi Al Qattarah dam



Collecting reservoir in small catchment

Fig. 7: Example of water harvesting structures in Al Jabal Al Akhdar

Modern technologies can make water harvesting more practical and lower in cost. Many of these technologies are available now and developments in science have contributed to their success. The problem is that farmers and communities do not have the knowledge or the means to implement suitable techniques in the appropriate way. Moreover, the capacity of the communities, the national research programs and extension services needs enhancement in the area of water harvesting [5].

Since the beginning of the former regime, many initiatives and actions plans related to surface water harvesting of Al Jabal Al Akhdar were proposed.

The most recent is the agreement of cooperation between the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Agricultural Research Center (ARC) in 2007 to boost collaboration for five years through the support of a trust fund from Libya to launch an integrated program of research-for-development in Libya covering three major areas water harvesting, improving cereal productivity and improving small-ruminant productivity [5].

The main water harvesting structures are the dams as shown in the Table (3) that illustrate constructed and proposed dams in Al Jabal Al Akhdar. Many of the studies were implemented, but mostly targeted for protecting the urban areas from flooding where there are no plan of action to exploit water that collected from these dams and that the combination of evaporation and the nature of rocks, lakes dams do not allow the survival of water for a long time In Al Jabal Al Akhdar water harvesting structures are vary in the capacity of water holding, as shown in Figure (7).

Non Conventional Water Resources: Large increases in water demand with limited recharge have strained Libya's groundwater resources resulting in serious declines in water levels and quality due to their over-exploitation, especially along the Mediterranean coast where most of the domestic, industrial and agricultural activities are concentrated [13]. Therefore, investment in and development of non-conventional water resources has become crucial for Libya. The main non-conventional

water resources are desalination and treated wastewater. The following is a summary of each.

Desalination: Desalination technologies have been used in Libya since the early sixties mainly by companies exploring for oil in water-short locations [13]. The use of different desalination technologies makes Libya one of the leading countries in this specific field over the past 30 year's. Where it is ranked as [14]:

- First in North Africa and the Mediterranean basin.
- 7th worldwide in General dependence on Desalination as an Urban Water Resource.
- 5th worldwide in using MSF technology.

According to Wheida and Verhoeven [15] the country faces many problems and difficulties associated with desalination technology applications as follows:

- The absence of a national authority specialized in seawater desalination has led to an ultimate dependence on foreign contracting companies for design, construction, operation and maintenance of desalination plants. Sometimes these foreign companies have different aims from the local authority in conducting their works.
- The absence of information exchange and poor documentation causes many repetitions of mistakes in conducting design and operational works.
- The uncertainty of any future strategy together with the absence of training programs for the operation of different kinds of technologies has a major negative impact on production efficiency.
- Some of the sites were not selected accurately with regard to avoiding long-shore currents, marine weeds and too great temperature differences, causing damage to some of the equipment or lowering the efficiency after a short period of installation.

- Competitive contractors offered unreliable equipment at low prices and there is a lack of laboratories, which are an essential part to guarantee the production quality of desalination plants.
- Implementing some stations of capacity beyond the average demands causing either a high production price or discontinuities in the production process.
- High production costs as a result of choosing unsuitable technology.

The common desalination technologies used in Libya Kershman, *et al.* [14] are:

- Multi stage flash (MSF)
- Multi effect desalination and vapor compression (MED & VC)
- Reverse osmosis (RO)
- Electro-dialysis (ED)

Desalination technologies were implemented in Al Jabal Al Akhdar from the year 1975 up to present, as indicated in (4) and are shown in Figure (8). The General Electric Company (GECOL), which was the responsible for the desalination plants operations and management, categorized desalination technologies according to their long experience into the following categories [14]:

Category A: Plants characterized by small units and with limited local know-how. Most of the units of this category are currently out of operation.

Category B: Units are of Medium Size, with GECOL taking over the responsibility of the sector.

Category C: Plants that are currently under construction or contracted for

Category D: Planned Projects up to the year 2012

Table 4: Desalination Al Jabal Al Akhdar [14]

Category	Name	Location	Operation year	Capacity m ³ /day	Status
A	Derna I	Dernah	1975	9,400	Not working
A	Sussa I	Susah	1982	13,500	Not working
B	Bomba	Bomba	1990	40,000	working
B	Derna II	Dernah city	1999	5,000	Not working
B	Sussa II	Susah	2000	10,000	Not working
B	Abu Taraba	Tolmitha	2008	40,000	working
C	Derna III	Dernah	2010	40,000	working
C	Sussa III	Susah	2010	40,000	working

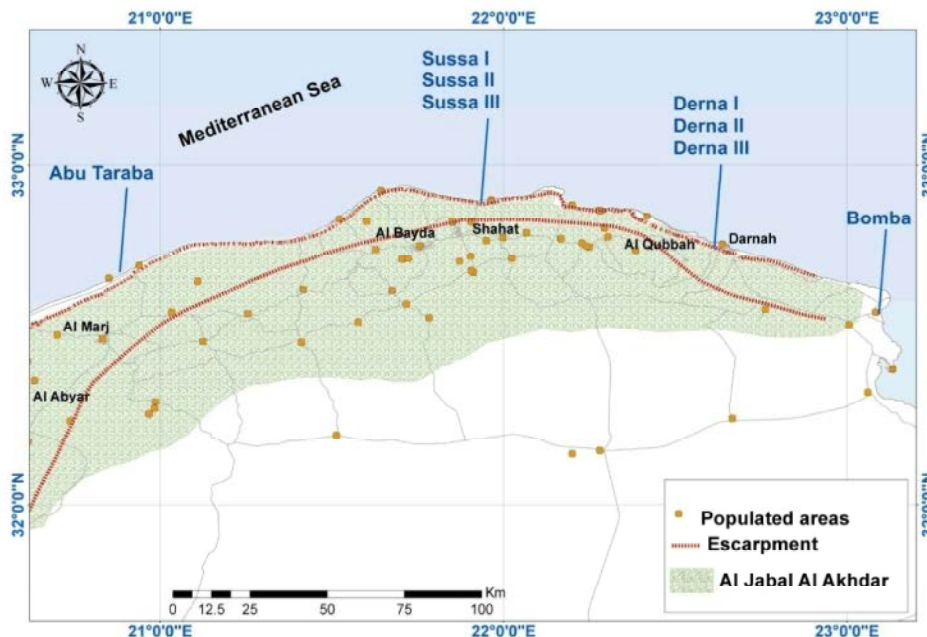


Fig. 8: Location map of desalination plants in Al Jabal Al Akhdar

GECOL experienced several operational problems with desalination plants, resulting in tremendous reduction of its availability, due to the lack of the local experience. These plants' major problems are [14]:

- Seaweed Growth.
- Corrosion and scale deposit.
- Operational problems.
- Unavailability of Water Transport and Distribution Systems.

It is expected that desalination will play an ever-increasing role in the future of Libya's development, not only to ensure the continuous supply of water to existing communities and industries in particular, but also to allow for the development of new ones as well. Moreover, it has a special strategic role as a readily available alternative standby source in cases of partial or total failure of the existing traditional sources of water [13]. Therefore, a strong policy is needed to implement desalination within the existing system. It is time to prepare a national act to create ways and means to benefit from all new desalination development since production costs have begun to decline [15].

Treated Wastewater Recycling: An inadequate sanitation system in the urban agglomerations, mostly in Al Jabal Akhdar but also around most of the cities of the south, leads to severe pollution of the shallow aquifers around

the cities [16]. In Libya treated sewage water constitutes a huge possible water resource as about 80 percent of the water consumed by the domestic is generated as sewage [17]. Only 60% of households are connected to a waste liquid disposal network, while 40% are using septic tanks [18], thus consequently leading to the pollution of groundwater.

As the Libyan population grows, more water will be required to satisfy their needs. The present limited water resources will get even more and more limited. This very much-needed water might come at a high financial and ecological price in the future. Currently the water demand markedly exceeds the conventional water resources capacities creating an urgent need for integrated water resources management with special focus on non-conventional water resources, namely wastewater re-use [19].

The spectacular views, unique environment and richness in the natural resources of Al Jabal Al Akhdar are threatened and suffer from pollution due to the direct flow of wastewater streams, as illustrated in the Figure (9).

A technology for water recycling of wastewater in Al Jabal Al Akhdar area were implemented since the 1964 and suffers from the same operational and management problems as in the desalination technologies. Table (5) indicates the wastewater treatment plants in the Al Jabal Al Akhdar. The General Company of Water and Wastewater is the responsible for the construction, maintenance and operations of these treatment plants.

Table 5: Overview of wastewater treatment plants [21]

Treatment plants	capacity, m ³ /day	Statuses
North Al Baydah	2500	Working
Massah	2500	Working
Shahat	6000	Working
Qernadah	2500	Working
Al Abyar	7400	Working
Al Marj	21000	Under maintenance
Ghariqa (Al Byda)	9000	Under maintenance
Qaser Libya	500	Under maintenance
Um Hufayn	500	Under maintenance
Labraq	500	Under maintenance
Qayqab	500	Under maintenance
Total	52900	



Fig. 9: Wastewater flow in Al Jabal Al Akhdar

A survey of domestic wastewater recycling that has been presented by Wheida and Verhoeven [20] led to the following:

- Recycling domestic wastewater has been successfully implemented in Libya since 1963, with some problems associated with operation and maintenance.
- Wastewater treatment plants are being used to generate water only in two major cities for agricultural purposes.
- The existence of larger plants in major cities surrounded by agricultural areas makes the cost of treated water conveyance minimal.
- Due to water shortage, human health protection issues and the economic advantages of efficient irrigation techniques make the role of treated water use become larger.
- Public confidence in using products that have been irrigated by treated wastewater requires educational health programs.
- The farmer's reluctant attitude towards using treated wastewater could be changed by a persuasive and encouragement policy.
- The inability of operating most of treatment plants to its design capacities caused by an incomplete sewer system in urban areas.
- Low sewage inflow due to the inefficiency of some pumping stations that lack spare parts and receive inappropriate maintenance.
- The shortage of spare parts and the absence of skilful personnel in operating have caused a smaller treatment production in some plants and a total closure of many others.
- Too low salaries cause technicians to refuse working in this field and result in an administrative unstable situation concerning to operation of treatment plants.

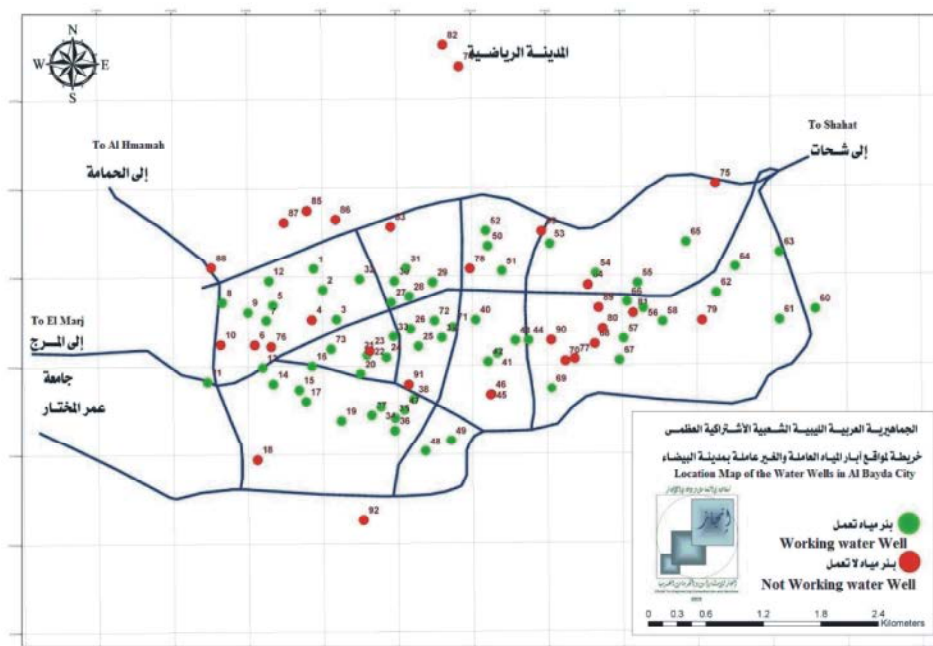


Fig. 10: Distribution of the water wells in Al Baydah City [23]

Water Use: Water use categories in Al Jabal Al Akhdar are municipal, agricultural and industrial. Desalinated water is used only for domestic purposes, while groundwater and surface water are used in all categories. Estimation of groundwater extraction from water wells and other surface water harvesting structures in Al Jabal Al Akhdar is not precise due to the lack of flow meter gauges, periodical inventory and the lack of integration between water institutions.

Cable tool percussion method used for water wells drilling and mostly in improper design and distributed in the urban areas as shown in Figure (10) which illustrates the distribution of the water wells in Al Baydah City in which the groundwater used for municipal purposes is in risk of pollution due to the absence of the proper sanitation networks.

In addition, high fraction of the extracted water is lost as leakage and unaccounted-for-water (UFW) because of the invalidity of the existing water transport and distribution facilities within urban areas due to the lack of the urban development during the former political regime.

Table (6) displays groundwater extraction volumes in Al Jabal Al Akhdar area for the year 2005 and was issued by GWA in 2006 in their report on water resources status in Libya. Groundwater extraction from the various hydrogeological units is used mainly for domestic and agricultural purposes.

Water Demand: In Libya municipal water demand has increased markedly in the last 4 decades in response to high population growth rates and increased per capita consumption. Per capita water use rates vary from 150 to over 450 liters per day [24]. For the agricultural sector, it is estimated that at least 80 percent of agricultural production depends on irrigated agriculture. However, yields from rainfed as well as irrigated agriculture is generally low [25].

Demand for domestic use in the three municipalities for the year 2006 is indicated in Table (7). Future water demands for the year 2025 are estimated based on the anticipated population for these three municipalities provided by the General Information Authority and using an average water demand used by GWA at 250 liters/day.

Due to relatively low industrial activities in these municipalities, the demand for industrial purposes is generally very low. On the other hand, due to the volume of investments that have been implemented in agricultural projects and settlements, the demand for agricultural purposes is considerably very high, as illustrated in Table (8).

For estimating the water needs for agricultural purposes, GWA assumes that the average requirement per hectare in this region ranges from 4000 m³/ha/year to 6000 m³/ha/year for the composition of crops that are considered as a

Table 6: Groundwater extraction in Al Jabal Al Akhdar area [22]

Hydrogeological unit	Domestic (m ³ /y)	Agriculture And industrial (m ³ /y)	Total
1- Al Marj-Al Abyar	5,621,730	47,085,000	52,706,730
2- Al Qubbah Al Bayda-Al Bayyadah	13,210,080	59,130,000	72,340,080
3- Ras al Hilal-Darnah-Martubah	4,774,200	28,855,440	33,629,640
Total			158,676,450

Table 7: Demand for domestic use in Al Jabal Al Akhdar area [26]

Municipality	Populations year 2006	Demand m ³ / year	Populations year 2025	Demand m ³ /year
Al Marj	169,653	15,480,836.3	241,516	22,038,335.0
Al Jabal Al Akhdar	211,972	19,342,445.0	308,686	28,167,597.5
Darnah	146,872	13,402,070.0	217,260	19,824,975.0
Total	530,503	48,225,351.3	769,487	70,030,907.5

Table 8: Demand for for agricultural in Al Jabal Al Akhdar area [26]

Municipality	Project	Total area in hectare	No of farms	Irrigated area in each farm (hectare)	Total irrigate area (hectare)	Demand m ³ /year
Darnah	Al Fatyah	1,305.0	261	5	1,305.0	6,525,000.0
	Sidi Aun	820.0	82	5	410.0	2,050,000.0
Al Jabal Al Akhdar	Al Jabal Al Akhdar	10,000.0	454	5	2,270.0	11,350,000.0
	Wsaityah	2,500.0	83	5	415.0	2,075,000.0
Al Marj	Al Fatah	160,000.0	1420	6	8,520.0	42,600,000.0
Total	174,625.0	2300		12,920.0	64,600,000.0	

Table 9: Proposed water well fields in Al Jabal Al Akhdar area [26]

Well field	No of proposed wells	Proposed production m ³ /year
Wadi Al Aysh	5	788,400.00
Al Baniah	5	788,400.00
Al Gharaib	10	1,576,800.00
Zawayt Al Arqub	30	3,942,000.00
West Al Hysha	25	3,942,000.00
East Al Hysha	50	7,884,000.00
Marawah	60	9,460,800.00
	195	28,382,400

winter field crop, such as wheat and barley as a major crop in need of supplementary irrigation in most and often focus on the intensive cultivation of olives and grapes, as well as some vegetables to meet the needs of the region. Moreover, the pastoral in the southern regions has been dedicated about 1,825,000 m³/year for watering animals.

Future Plans: In 1999, Libya has formulated a 25 year (2000-2025) water strategic plan; this strategy was approved in May, 2005. Its ultimate objectives were to stop continuing water deficits and quality deterioration and set a base for sustainable development to maintain present living standards,

while securing the same rights for future generations [24]. For agricultural demands the former political regime was planning to supply Al Jabal Al Akhdar from the GMRA project which is not implemented yet. Regarding the domestic sector, a plan for supplying the urban areas from new well fields Table (9) was proposed. The plan was suggested by GWA and confirmed by exploratory drilling. These well fields were designed and some of the required hydraulic structures are implemented.

Agricultural demands are proposed to be covered through the transfer of water from the first stage of the Great Manmade River, through the transmission pipeline Ajdabiya - south Al Jabal Al Khdar.

CONCLUSIONS

Al Jabal Al Akhdar is relatively rich in water resources and has varieties of water resources (groundwater, surface water, desalination and wastewater), however, these resources are mismanaged properly in integrated comprehensive approach.

It is argued here that the challenge of the water resources in Al Jabal Al Akhdar is a management challenge first and then a technical one. Taking into consideration the issues of increasing water demand driven by population growth and urbanization and uneven distribution of water resources and quality degradation, water resources management in Al Jabal Al Khadar face many challenges and constraints, which can be concluded as in the following:

Institutional:

- Centralization in planning and financing
- Limited budget and financial resources
- The overlap of water institutions
- The lack of coordination between the water institutions
- Organizational instability
- Limited structuring among the functional levels
- Inadequate institutional capacity at regional and local levels
- Limited experience in integrated management
- Less participations of the stakeholders

Human:

- Socio-economic dimensions are insufficiently reflected
- Less in capacities in water management
- Limitation in skilled labor and insufficiently prepared for coping with future challenges
- Absence of an organized long-term approach to awareness raising activities
- Lack of financial incentives to workers in water institutions.

Legislative:

- Some laws conflicting with water resources conservations.
- The adoption of laws governing the protection of some water resources not associated with implementation procedures and no supplementary economic opportunities.

- Some of the decisions those made disposing of legal prerogatives to intervene in the scope of water.
- The enforcement of water laws made by different parties in less integrated manner.

Technical and Environmental:

- Lack of Monitoring water resources
- Lack and quality of data
- Absence of proper specifications and technical procedures

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