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Evaluation of water resources in Libya: Current challenges and measures to address them

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ABSTRACT

The demand for food security cannot be achieved without ensuring water security, as water is the essential substance upon which all human requirements and activities depend. Any impact on this resource negatively affects living organisms, especially humans. Groundwater in Libya is being depleted due to irrational pumping for agriculture, industry, and population growth, causing an increase in water deficit and depletion of surface water resources. This has resulted in gaps between what is available and what is needed to meet growing demands. Available surface water in northern regions is one of the most important sources for the country. Sixteen major dams have been constructed to preserve rainwater, totaling approximately 385 million cubic meters of water. By 2035, the demand for drinking and household water use is expected to increase to more than 1100 million cubic meters to meet the needs of 8.2 million people. The poor infrastructure of the General Company for Water and Wastewater has resulted in the loss of large amounts of water, reaching around 50% of the company's total supply network. This study aims to identify natural water sources and the importance of tackling their deterioration to preserve food security in the face of climate change and the increasing demand for clean drinking, agricultural, and industrial water.

Keywords: Nature water resource, confrontation water deterioration, food security.

INTRODUCTION

According to Bilalova *et al* (2023), integrated Water Resource Management (IWRM) is often viewed as an ambiguous concept. While there is no universal definition, both international and national definitions of IWRM share commonalities, particularly in their focus on multiple objectives and sustainability considerations. In this paper, we will refer to a widely accepted definition established by the Global Water Partnership (GWP) in 2000, which describes IWRM as a process that promotes the coordinated development and management of water, land, and related resources. Food security and sustainable development cannot be achieved without a secure water resource that recognizes its essential value for human survival and well-being. Libya is one of the countries experiencing a shortage of available water resources to meet the needs of drinking water, food industries, and other related industries (FAO, 2023).

The absence of safe drinking water and its neglect is considered a failure in addressing water and food security (Abu Rawin & Bashir, 2001). The availability of both seasonal and permanent wells is crucial to provide water for irrigating agricultural lands in Libya. The state of Libya has an area of about 1.7 million km^2 with a total population of about 6.5 million. Ninety percent of the people live in less than 5% of the land, mostly along the coast. The population density in the central and southern parts of the country is below $1/km^2$ (Brika, 2018). There are approximately 15 wells in the region, with the most productive one being Ain Zayana, which produces about 120 million cubic meters of water per year (FAO, 1996). However, the seawater interference affects this source. Another significant source is Ain Taworgha, producing about 60 million cubic meters of water per year for agricultural and other purposes. Moreover, there are numerous seasonal valleys, such as Wadi Sof-al-Jenn, Wadi Kaam, Wadi Al-Majinin, and Wadi Al-Cittara, which result in flooding and flow into the sea.

Contamination of water due to human activities is a serious concern as it disregards the country's resources and security (Abu Rawin & Bashir, 2001; Al-Barouni, 2000). Like many other countries, Libya also faces significant water scarcity issues, particularly due to the lack of fresh surface water. Furthermore, excessive use of groundwater in agriculture has led to its depletion and the closure of some wells (Al-Barouni, 2000). In other hand, Yassin (2021) has reported that Libya and to propose alternative solutions by renewable and sustainable energies. This problem is not only in Libya, but it is one of the most serious social and environmental challenges facing many countries in the world (Hamad, 2022).

The Great Man-Made River Project was implemented to address the deterioration and scarcity of water. The project's goal is to transport 6.18 million cubic meters of water per day from the desert to the fertile residential and agricultural lands in the north through a 4000 km long Khorasan pipeline. Unfortunately, the project has faced frequent attacks, resulting in nearly 190 wells becoming inoperable. This has led to network degradation and imminent danger to water supplies, making it challenging to regularly meet the needs of cities and agricultural projects (Abu Rawin & Bashir, 2001; Al-Barouni, 2000). Over four million people, including 1.5 million children, are facing water shortages. The water desalination stations are experiencing a lack of operational and necessary chemical materials for maintenance. As a result, some stations, like the Guleej station, have gone out of service, affecting more than 63,000 people (Heemskerk & Koopmanschap, 2012).

The Ministry of Agriculture and the Ministry of Water Resources have developed and implemented plans to drill and maintain underground water wells suitable for drinking, urban use, and agriculture. This is to ensure water security and food security. Water security means having reliable access to a sufficient quantity and quality of water that is safe for health, livelihoods, and production while also managing water-related risks (FAO, 1996). Food security is achieved when everyone always has access to enough safe and nutritious food to lead an active and healthy life. The United Nations Food and Agriculture Organization has identified four pillars of food security: availability, access, use, and stability (Heemskerk & Koopmanschap, 2012).

Libyan geographical location and climate:

Libya is situated in North Africa on the southern coast of the Mediterranean Sea. It has a large area of 1,600,000 sq km and is influenced by the Mediterranean climate. With about 93% of Libya’s land surface receiving less than 100 mm/year rainfall, desertification and very limited natural fresh water resources are the current and significant environment issues in Libya (Abdudayem & Scott, 2014). The climate varies from semi-desert in the south, including the southern slopes of the Green Mountain and Nefusa Mountain, to desert in the southwestern border with Tunisia, and fully desert in other areas. Rainfall in Libya is mainly concentrated in the winter, with maximum rates reaching up to 200 mm in the northern region, 500 mm in the eastern mountain regions, and 50 mm in the central region. The northern region experiences the most rainfall, while the desert climate in the north of the Mediterranean means that the south usually does not receive much rainfall. Over the study period, Libya has experienced significant population growth (Wheida & Verhoeven, 2007), increasing from about 1,088,000 in 1954 to approximately 5,673,031 in 2006, as shown in Table (1).

Table (1): The increase in the population and the annual rates of population increase for this period.

Years	Libyans	Total No. of inhabitants	average development for Libyans
1954	1,041,600	1,088.882	-
1964	1,515,501	1,564,369	3.8
1973	2,052,372	2,249,237	3.4
1984	3,237,059	3642576	4.21
1995	4,389,739	4811902	2.86
2006	5,323,991	5673031	1.83

The climatic and environmental conditions have had a significant impact on population distribution. More than 82% of the total population is concentrated within 40 km from the country's east and west coasts, while the remaining population resides in scattered oases and small population centers. According to the data, Libya's population growth rate peaked at 4.21% during 1973-1984, decreased to 1.83% during 1995-2006, stabilized at around 1.8% during 2006-2010, decreased to around 1.6% during 2010-2015, and then stabilized at around 1.5% after 2015. It is projected that the population will reach approximately 8.2 million by 2035. With the population increase and changing lifestyles, each individual's share of water will rise, leading to an estimated total domestic water demand of about 1100 million m3 by 2025 (Hamad, 2022). The United Nations Children's Fund (UNICEF) warned in a report that over 4 million people, including 1.5 million children, are at risk (Salim, 1997).

Table (2): shows population growth and expected water needs for urban use during the period (2035 – 2006).

Year	2006	2010	2015	2025	2035
Estimated Libyan population in millions	5.3	5.7	6.2	7.2	8.2
Estimated total in a million people	*6.3	6.9*	7.7*	8.7*	9.7*
Estimated per capita consumption (liters per day	250	300	300	300	300
Water needs (million cubic meters per year)	575	756	843	953	1100

*** represents the difference between the total population and the Libyan population**

Subterranean water refers to the groundwater that seeps from aquifers through an unconfined domain (Al-Qabli, 2001). In Libya, it is the primary source, contributing over 97% of the total water consumption and serving as the sole source available for agricultural, industrial, and drinking activities. The water sources in Libya are categorized into the following systems or water basins: Gefara Plain, Gadames, Hamada Alhamra, Marzug, Benghazi Plain, Jabal Alakhdar Sirte, and Kafra (Wheida & Verhoeven, 2007).

Springs are important water sources for some cities and have various uses. Geological factors like earth fissures, karst phenomena, and rain infiltration significantly affect the presence and productivity of springs (FAO, 1996; Wheida & Verhoeven, 2007). A General Authority for Water (2006) puplished about the productivity of springs can range from 0.5 liters per second to 4200 liters per second, as shown in Table 3. Some springs provide fresh drinking water, with most having less than 1000 milligrams per liter of dissolved solids, such as some springs in Jabal Alakhdar. However, others contain salty or highly brackish water and are not suitable for drinking (UNICEF, 2020).

Table (3): The most important water springs in Libya and their productivity in liters per second.

No.	Place	Production (L/s)
1	Azyana	4200
2	Tawergha	2000
3	Kaam	360
4	Aldabousa	140
5	Oyoun Al Jabal Al Akhdar, Al Duban (Ghadames), Al Ghazala, and others	0.5-10

Surface water: One of the most important sources of water in the northern part of the country is the 16 main dams with a total capacity of approximately 385 million cubic meters of water. These dams are essential for preserving rainwater, protecting cities from floods, and rehabilitating new land. As Internet Information Network (2020) mentioned that among these dams, Ku'Aam, Qatara, and Majeenin (in succession) are the most significant, with a combined capacity of 304 million cubic meters of water. However, due to the lack of rainfall, the water levels in these dams have decreased to about 60-70 million cubic meters per year (Abu Rawin & Bashir, 2001).

Freshwater desalination has become increasingly important due to the high demand for drinking water. Along the Libyan coast, several desalination plants have been established in cities and major industrial complexes to provide fresh water to the population and industrial facilities. Most of these plants rely on seawater as their primary source. While some plants are designed for treating brackish and slightly saline water, their production efficiency is limited. However, there has been an increase in the number of plants with a capacity of more than 500m3/day, serving factories, hospitals, and hotels (Dickin, 2023). Due to a shortage of operational materials and chemicals needed for maintenance (FAO, 1996 & National Strategy for Sustainable Development, 2008)، 75 stations have been suffering, and some have gone out of service. As a result, annual production has decreased from 71 million m^3 in 2010 to 70 million m^3 in 2012.

Table (4): Some seawater desalination plants produced.

No	Station	Capacity - m3/day			Starting year
		Design	2008	Current	
1	Tubrouq	64,000	52,000	Suffering from the lack of operational materials and chemicals needed to carry out maintenance, which resulted in some stations being out of service	2002-1977
2	Albuma gulf	30,000	18,000		1990
3	Derna	5,000	5,000		2000
4	Souse	10,000	10.000		2007
5	Abutraba	40,000	40,000		2005
6	North Benghazi	5,000	5,000		1986
7	Sirte	10,000	7,000		1982
8	Zliten	30,000	20,000		1992
9	Khoms	42,000	30,000		1982
10	West Tripoli (2)	10,000	10,000		1999
11	Zawara	40,000	40,000		2005
Total		286,000	237,000	**70 million m3/year**	2012

Since the 1980s, 75 wastewater treatment plants have been constructed in major cities in Libya, with a design capacity of 450,000 cubic meters per day. The purpose of these plants is to provide additional water resources for irrigation, green spaces, and animal feed production to meet food security needs and protect public health (Wheida & Verhoeven, 2007). However, most of these plants are operating inefficiently with very low flow rates due to technical and non-technical issues (FAO, 1996), and some of them are not functioning at all or are incomplete. It is also necessary to implement upgrade programs for these plants (Al-Barouni, 2000; Al-Qabli, 2001). The annual capacity of these plants was about 25 million cubic meters per year in the latest statistics. The inadequate infrastructure of the public water and sanitation company also leads to significant water loss from the company's networks (FAO, 1996).

Reports on the Industrial River in (2006) have declined of groundwater: Expansion in rain-fed agriculture, which relies primarily on groundwater to achieve self-sufficiency in agricultural and animal products and ensure food security, has resulted in the consumption of over 77% of the total annual water supply (Wheida & Verhoeven, 2007). Water scarcity is one of the current greatest challenges in Libya and will be the case in the future if no serious decisions are taken to solve this dilemma. According to some reports; Libya is one of the top countries facing water stress, with a baseline water stress score of 4.84. It has been constantly ranked as one of the most water-insecure places in the world (Brika, 2018) The excessive extraction of groundwater in the coastal areas of the Sebha plain has led to a decrease in water levels by 1-3 cubic meters per year. With the growing demand for water, annual consumption has risen (Wheida & Verhoeven, 2007) from 210 million cubic meters in 1962 to 1049 million cubic meters in 2005.

The water resources in the Marzag Basin face a major challenge due to increasing demand from private farms. In 2005, these farms used around 1600 million cubic meters out of the total 1913 million cubic meters of water used for agricultural purposes. This accounts for about 41% of the total water consumption in Libya. Other areas in Libya are also experiencing a noticeable decline. Population centers like Tajourah, Zawia, and Nalut, which lack water treatment plants, have contributed to this decline (Al-Barouni, 1997).

Table (5): Water needs (million cubic meters/year).

year	*1998	**2005	**2010
Farming	3335	3800	-
urban use	453	603	-
industry	136	500	-
Total	3924	4905	6352

Source: *Al-Barouni (1997); **Aldeeb, & Aldabusi (2023).

Environmental challenges: Studies indicate a pressing need to protect water resources. The excessive exploitation of water exceeds safe limits, causing natural water reservoirs to be overtaken by seawater. This results in a shortage of water supply and the intrusion of seawater along the coastal strip. To compensate for the loss of fresh brackish water, an estimated 166 million cubic meters of seawater annually are easily desalinated. However, this intrusion leads to an increase in water turbidity, exceeding local and international standards, making the water unsuitable for drinking, industry, and agriculture. This issue is prevalent in areas such as Tripoli (Tajoura, Benghazi, Swani), Benghazi (Binina), Misserata (Tameen), and Zawiya. International Internet Information Network, (2020) mentioned that there is a notable difference in the concentration of dissolved solids in some selected wells near the sea (Wheida & Verhoeven, 2007), as observed in the Tameen Agricultural Project (1995-2000) according to Table (6).

Table (6): Estimates of Solids Concentration in Well Water at the Tameen Agricultural Project (in parts per million).

Well No.	year 1995	Year 2000
1	2000	9900
5	2200	8500
6	1450	8640

In Libya Water Sector M & E Rapid Assessment Report (2014), efforts have been made to address water depletion and shortages for agriculture and urban use. This includes the enactment of several laws to regulate water resources, such as Law No. 3 of 1982 on the regulation and use of water sources, Law No. 7 of 1982 on environmental protection, and Law No. 15 of 1371 on the protection and improvement of the environment. Hydrological studies have been conducted on water basins, water treatment stations have been constructed, successful rainfall harvesting operations have been carried out, a national panel has been established to develop long-term strategic solutions to the growing water shortages in Libya, and projects like the industrial river have been implemented (Wheida & Verhoeven, 2007) as shown in Table (7).

Table (7): Information about the artificial river.

Project implementation start	**The aim of the project**	**Project contribution**	**concrete pipe length**	**Run the first stage**	**Run the second stage**	**total production of the two phases until the end of 2006**	**the current time** 2022
1984	Transferring 6.2 million cubic meters of water per day from southern Libya to coastal areas	Providing water suitable for drinking, agriculture and other urban uses	4000 km	August 1993 219,685,000 million m3 of water per day	September 1996 209,950,000 million cubic meters of water per day	More than three billion m3 of water per day	Repeated attacks on the man-made river systems

Present Challenges and Future Prospects:

In Libya Water Sector M & E Rapid Assessment Report (2014), the expansion of irrigated agriculture, mainly relying on groundwater, has led to a decrease in the quantities of groundwater. Studies on this issue emphasize the need to protect water resources in order to achieve food security (Al-Barouni, 2000). It is expected that water resources per capita will decline from 170 cubic meters per year in 1995 to 70 cubic meters per year in 2025. The United Nations Children's Fund has estimated that more than 4 million people, including 1.5 million children, are exposed to the risk of water scarcity (Al-Barouni, 1997). A significant gap exists between academic advancements in water management and their practical application in policymaking, highlighting the need for an inclusive, equitable, and context-specific global cooperation model (Evaristo *et al*., 2023).

The level of water consumption in the Marzuq basin has reached a high level, even with the current investment methods. There is a deficit between the availability of 1800 million cubic meters and the current consumption of around 390 million cubic meters annually (General Authority for Water, 2006) with two specific objectives in mind. The first objective is to compare disparities between Member States (MSs) in a particular year and track their progress over two periods of five- and ten-years concerning variables related to water resources and sanitation services (Dickin, 2023; Brika, 2018). For the Kufra and Sirte basins, exploitation rates are not expected to lead to negative effects. However, the water balances in the coastal, Green Mountain, and western mountain regions are at risk (Abu Rawin & Bashir, 2001, Al-Barouni, 1997).

About Water quality, Hamad (2021), reported that the statistics of the chemical parameters and major ions for the wellfield's water wells in Libya contain the majorities types of water, according to the Piper diagram, are Mg–K–Na–HCO3, Mg–K–Na–HCO3–Cl, and Mg–Na–K–HCO3, which reflect the carbonate and silicate weathering and cation exchange of ferromagnesian minerals. Similar study was made in Libya (Sebratha City) were the Canadian Council of Ministers of the Environment WQI (CCMEWQI) and the Weighted Arithmetic WQI (WAWQI) were used to assess the groundwater quality for drinking purposes and ten samples were collected from different sites. Eleven significant parameters were considered for calculating the WQI such as; pH, total dissolved solids (TDS), calcium (Ca++), magnesium (Mg++), sodium (Na+), potassium (K+), Chloride (Cl-), bicarbonate (HCO3-), Sulfate (SO4--), nitrate (NO3-) and Total Hardness (HD), only 20% of the samples were classified as suitable for direct consumption (Wafa & Bashir., 2023).

Necessary information for policymakers and stakeholders to adopt beneficial strategies for mitigating the present crisis and ensuring that groundwater resources in Zliten are sustainable over the long run were reported by (Dickin, 2023). In addition, the true cost of water provision often extends to ecosystem services such as watershed protection. Often, these services are not internalized in the revenue models of utilities but are typically subsidized by governments or simply not considered. Balancing affordability for users with cost recovery for service providers (Evaristo *el at*., 2023).

Conclusion:

Water scarcity is one of the biggest problems facing sustainable development and food security in Libya. Libya relies mainly on groundwater for all vital purposes. Due to the lack of maintenance and failure to keep pace with technological developments, the water supply is threatened, which impacts the ability to meet the needs of cities and agricultural projects regularly.

Recommendations

It is necessary to implement restricted programs to protect water resources and improve water usage efficiency in agriculture. It is also important to maintain and develop sewage treatment stations and update hydrological databases and water monitoring networks. Enhancing public awareness is crucial to rationalize water consumption.

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تقييم الموارد المائية في ليبيا: التحديات الحالية والتدابير اللازمة لمواجهتها

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المشتخلص

لا يمكن تحقيق الطلب على الأمن الغذائي دون ضمان الأمن المائي، فالماء هو المادة الأساسية التي تعتمد عليها كافة متطلبات وأنشطة الإنسان، وأي تأثير على هذا المورد يؤثر سلباً على الكائنات الحية وخاصة الإنسان. وتتعرض المياه الجوفية في ليبيا إلى الاستنزاف بسبب الضخ غير الرشيد للزراعة والصناعة والنمو السكاني، مما يتسبب في زيادة العجز المائي واستنزاف موارد المياه السطحية، مما أدى إلى وجود فجوات بين ما هو متاح وما هو مطلوب لتلبية الطلبات المتزايدة. وتعتبر المياه السطحية المتاحة في المناطق الشمالية من أهم المصادر للبلاد. وقد تم إنشاء ستة عشر سداً رئيسياً لحفظ مياه الأمطار، بإجمالي حوالي 385 مليون متر مكعب من المياه. ومن المتوقع بحلول عام 2035 أن يزيد الطلب على مياه الشرب والاستخدام المنزلي إلى أكثر من 1100 مليون متر مكعب لتلبية احتياجات 8.2 مليون شخص. وقد أدى ضعف البنية التحتية للشركة العامة للمياه والصرف الصحي إلى فقدان كميات كبيرة من المياه، تصل إلى حوالي 50٪ من إجمالي شبكة إمدادات الشركة. تهدف الدراسة إلى التعرف على مصادر المياه الطبيعية وأهمية معالجة تدهورها للحفاظ على الأمن الغذائي في ظل تغير المناخ والطلب المتزايد على المياه النظيفة للشرب والزراعة والصناعة.

الكلمات المفتاحية: مصادر المياه الطبيعية - مجابهة تدهور المياه - الأمن الغذائي .