

An Analytical Case Study of the Man-Made River Project

Libyan Hydraulic and Water Resources Management Opportunities and Challenges

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Abstract

There is no doubt that securing human water needs is both a challenge and a problem. Water management is vital for poverty reduction, environmental sustenance, and sustainable economic development. In view of the rapid increase in population, urbanization, and industrialization, the demand for water to meet various requirements is continuously increasing. Therefore, we are facing numerous challenges in the water sector, which include reducing per capita water availability, the decline in groundwater table in many areas, and saltwater intrusion in coastal aquifers. The quality of surface water and groundwater is also deteriorating because of increasing pollutant loads from various sources. Climate change may also adversely affect the availability and distribution of water resources. In order to attain water security, the Libyan government concentrated on making investments in the groundwater sector, particularly because Libya has the greatest groundwater reserves in Africa, amounting to about 95,000 km³. Established as the primary source of water supply for over 70% of Libyan cities, the Man-Made River project has grown to be a strategically significant choice. However, even after all phases are completed, it will only help secure 2.3 billion m³ of water a year. The real future water needs are estimated at around 10 billion m³ by 2035, which cannot be met by this amount. Therefore, alternative and supportive solutions for the river project are needed to reduce

the gap between what is available and what is produced, such as desalination of seawater and sewage treatment. The study aims to present the reality of the water sector in Libya. including some technical aspects and policies of dealing with the water resources sector, and thus trying to analyze the current challenges and problems and anticipate future problems faced by this sector, as well as publishing the most important available data and statistics and the results of periodic reports related to the state of water resources in Libya. The study used a variety of academic sources, including peer-reviewed articles, government reports, international publications, and academics and researchers interested in this field, to provide a comprehensive and evidence-based examination of the issues. Finally, the purpose of this paper is to contribute to the understanding of hydraulic and water resources management in Libya and to provide policymakers with insights into policies and practitioners in this field. The results of this study will be useful to policymakers and practitioners in Libya as well as countries facing challenges in water management. The study concludes that Libya's water crisis is multifaceted and involves more than just a quantitative shortfall of fresh water; it also involves high rates of population growth, waste, ongoing encroachment on the river system, poor management, and water pollution. The paper will provide recommendations for future research to further advance the understanding of hydraulic and water resource management in Libya.

Keywords: Man-Made River Project, Hydraulic, Water Resources Management, condition political.

دراسة حالة تحليلية عن مشروع النهر الصناعي: إدارة الموارد المائية والهيدروليكية. الفرص والتحديات

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الملخص:

ليس هناك شك في أن تأمين احتياجات الإنسان من المياه يمثل تحدياً ومشكلة في نفس الوقت. تعد إدارة المياه أمراً حيوياً للحد من الفقر، والحفاظ على البيئة، والتنمية الاقتصادية المستدامة. ونظراً للزيادة السريعة في عدد السكان والتحضر والتصنيع، فإن الطلب على المياه لتلبية الاحتياجات المختلفة يتزايد باستمرار. ولذلك، فإننا نواجه العديد من التحديات في قطاع المياه، والتي تشمل انخفاض نصيب الفرد من توافر المياه، وانخفاض منسوب المياه الجوفية في العديد من المناطق، وتسرب المياه المالحة إلى طبقات المياه الجوفية الساحلية. كما تتدهور نوعية المياه السطحية والمياه الجوفية بسبب زيادة كميات الملوثات من مصادر مختلفة. وقد يؤثر تغير المناخ أيضاً سلباً على توافر الموارد المائية وتوزيعها. ومن أجل تحقيق الأمن المائي، ركزت الحكومة الليبية على الاستثمار في قطاع المياه الجوفية، خاصة وأن ليبيا تمتلك أكبر احتياطي من المياه الجوفية في أفريقيا، يصل إلى حوالي 95 ألف كيلومتر مكعب. تم انشاء مشروع النهر الصناعي باعتباره المصدر الرئيسي لإمدادات المياه لأكثر من 70% من المدن الليبية ليصبح خياراً ذا أهمية استراتيجية. ومع ذلك، حتى بعد الانتهاء من جميع المراحل، فإنه لن يساعد إلا في تأمين 2.3 مليار متر مكعب من المياه سنوياً. وتقدر الاحتياجات الحقيقية من المياه في المستقبل بنحو 10 مليارات متر مكعب بحلول عام 2035، وهو ما لا يمكن تلبيته بهذه الكمية. ولذلك فإن هناك حاجة إلى حلول بديلة وداعمة لمشروع النهر لتقليص الفجوة بين ما هو متاح وما يتم إنتاجه، مثل تحلية مياه البحر ومعالجة مياه الصرف الصحي. تهدف الدراسة إلى عرض واقع قطاع المياه في ليبيا. بما في ذلك بعض الجوانب الفنية وسياسات التعامل مع قطاع الموارد المائية، وبالتالي محاولة تحليل التحديات والمشكلات الحالية

واستشراف المشاكل المستقبلية التي يواجهها هذا القطاع، وكذلك نشر أهم البيانات والإحصائيات المتوفرة ونتائج التقارير الدورية المتعلقة بحالة الموارد المائية في ليبيا. استخدمت الدراسة مجموعة متنوعة من المصادر الأكاديمية، بما في ذلك المقالات والتقارير الحكومية، والمنشورات الدولية، والأكاديميين والباحثين المهتمين بهذا المجال، لتقديم فحص شامل وقائم على الأدلة للقضايا. أخيراً، الغرض من هذه الورقة هو المساهمة في فهم إدارة الموارد المائية وفي ليبيا وتزويد صناع السياسات برؤى ثاقبة حول السياسات والممارسين في هذا المجال. ستكون نتائج هذه الدراسة مفيدة لوضعي السياسات والممارسين في ليبيا وكذلك البلدان التي تواجه تحديات في إدارة المياه. وتخلص الدراسة إلى أن أزمة المياه في ليبيا متعددة الأوجه وتتطوي على أكثر من مجرد نقص كمي في المياه العذبة؛ كما أنها تتطوي على معدلات عالية من النمو السكاني، والنفايات، والتعدي المستمر على نظام النهر، وسوء الإدارة، وتلوث المياه. وستقدم هذه الورقة توصيات للبحث المستقبلي لتعزيز فهم إدارة الموارد المائية في ليبيا.

الكلمات المفتاحية: مشروع النهر الصناعي، هيدروليك، إدارة المصادر المائية، الظروف السياسية.

Introduction

Water is an essential resource for sustainable development and socioeconomic prosperity, and its availability and management are crucial to the success of any nation. Due to Libya's arid and semi-arid climate, limited water resources dependent on nonrenewable aquifers and irregular rainfall patterns, and ongoing political instability, hydraulic and water resource management in Libya is a significant challenge for balancing competing demands from various sectors, including agriculture, industry, and domestic use. The challenge lies in ensuring equitable distribution, prioritizing water allocation, and minimizing conflicts among these sectors by creating water management policies and strategies supported by effective, appropriate institutional frameworks based on integrated water management approaches. This situation is of crucial importance, with implications not only for the future development

of Libya but also for the sustainability of its past economic and social achievements. The dilemma arises from escalating water demand, which is the result of population growth and agricultural policies, in conjunction with the fact that the region is already exploiting all of its water resources while its groundwater resources are rapidly depleting. The paper has examined the challenges and opportunities in managing water resources, with a focus on the Man-Made River Project (MMRP), which is one of the world's largest hydraulic engineering projects, designed to transport fresh water from the Nubian Sandstone Aquifer System in southern Libya to the coastal cities of northern Libya. This paper has provided a comprehensive analysis of the challenges facing hydraulic and water resource management in Libya, with a particular emphasis on the MMRP. The paper has also investigated the opportunities presented by the project for sustainable water management, as well as the potential solutions and strategies for addressing the project's challenges. The study has utilized a variety of academic sources, including peer-reviewed articles, government reports, and international publications, to provide a thorough and evidence-based examination of the issues.

Study Problem:

Libya suffers from a scarcity of its limited water resources despite the efforts made in this field, represented by building dams and establishing seawater desalination, in addition to the Man-Made River Project, which requires the necessity of rationalizing consumption of this vital and important resource, especially in the agricultural and economic sectors. The study aims to shed light on the current water resources, the current and future needs, the most important challenges facing them, and the proposed solutions to reduce this crisis. The study relied on the use of descriptive analysis methods in addition to some special indicators and standards for water resources by relying on secondary data from local sources issued by competent authorities interested in water resources in Libya, in addition to technical studies related to water resources and research related to the subject of the study.

Hydraulic Infrastructure in Libya:

Over the past several decades, dams, canals, and irrigation systems have been constructed as part of Libya's hydraulic infrastructure to support agricultural activities. However, the lifespan of the hydraulic infrastructure has deteriorated due to a lack of maintenance and investment over the years. Many of the dams have suffered structural damage and sedimentation, reducing their water capacity and their ability to store water (Abuzweda et al., 2018). The collapses that happened in both Derna dams (night of September 10–11, 2023) are evidence of this. Engineers analyzed the causes of this disaster and found that the lack of maintenance and permanent oversight of them was a result of the absence of supervisory authorities, the fragmented political situation, and the division of the country into areas of influence. Moreover, the irrigation systems are inefficient and require major improvements to reduce water losses and enhance water distribution to farmers. Libya's antiquated hydraulic infrastructure is the result of a lack of investment and maintenance. The state of political and economic instability that has prevailed in the country since the revolution has led to the emergence of unusual problems related to basic management. Despite the negative aspects of the previous government, the well fields of the Man-Made River project were always subject to the supervision of supervisors, and the various electricity stations belonging to the regime had ventilation systems and tanks that were under military protection around the clock. However, the current situation is characterized by a general lack of interest by state officials in the importance of water issues in general, and there is a disregard for the challenges facing the “Man-Made River” project. In addition, the state of instability in the institutional structure of the water sector is exacerbated by power outages and security fluctuations. For example, since the central monitoring room of the pipeline system for western Libya was bombed around early May, the water flow has dropped from the normal flow of 1.2 million cubic meters per day to about 800,000 cubic meters per day now, due to sabotage and a lack of funding and maintenance (Ahmed and Ulf, 2019). The government must allocate

additional funds to modernize and maintain the hydraulic infrastructure, as well as invest in the creation of new systems. The government must also enact and enforce laws and regulations to ensure that infrastructure projects are designed and constructed in accordance with contemporary standards. To improve the quality and safety of these systems, the Libyan government could adopt European standards for the design and construction of hydraulic infrastructure, for instance (Yuan et al., 2018). By modernizing and maintaining the hydraulic infrastructure, Libya can improve access to clean water and irrigation, which will ultimately lead to increased agricultural productivity and economic growth. Furthermore, investing in the creation of new systems will provide job opportunities for Libyan citizens and stimulate the economy.

Water resources in Libya

Because Libya's water resources are limited and unevenly distributed, it is imperative to manage it sustainably. The Man-Made River Project (MMRP), groundwater, and desalination plants are Libya's major water sources. The MMRP is a vast network of pipes and aquifers that transports water from aquifers in the south to coastal cities in the north. However, a lack of maintenance and investment has reduced the MMRP's ability to provide water to cities. The overexploitation of groundwater resources has led to a decline in their quality and quantity. In addition, the underutilization of desalination plants is due to the high cost of energy and the lack of investment in their development (Abuzweda et al., 2018). To address these challenges, it is crucial to prioritize maintenance and investment in the MMRP infrastructure. Additionally, exploring alternative energy sources and implementing technologies that are more efficient can help reduce the cost of desalination plants and increase their utilization. Table (1) and figure (1) below explain the amount of available water in Libya as reported by the Libya Institute for Advanced Studies (LIAS) (Mostafa, 2022).

Table (1): Libyan's Water Resources Source: Mostfa (2022)

Available water	Million m ³
Ground water	2557.62
Surface water	61.00
Desalination	47.86
Waste water	24.16
Total	2689.64

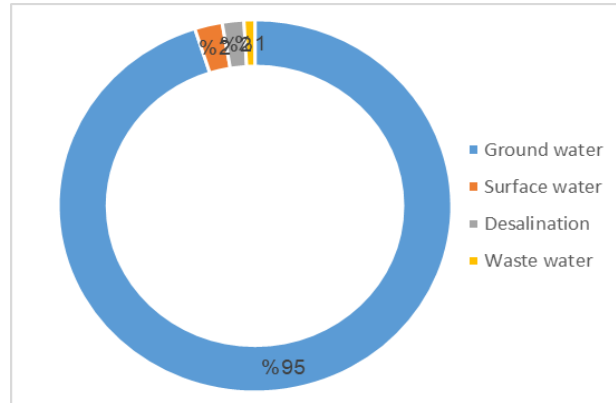


Figure (1). Libyan's Water Resources

Uses of water resources

The water demand is increasing with the increase in population as shown in figure (3) and economic and urban growth, and to avoid possible water crisis have so far been insufficient. The agriculture, domestic and industrial sectors are putting particular stress on demand as shown in figure (2). The irrigation and agricultural sectors consume the largest amount of water resources in Libya, at an average rate estimated at about 83.8%, while domestic uses

represent 12.4% of total consumption, divided between groundwater supplies and water generated from desalination plants and local wells. The quantity of water consumed in the industrial sector is estimated at about 3.8%, and the largest part is consumed in oil production processes at a rate of 78%, according to 2010 estimates (Al-Baroni, 2013).

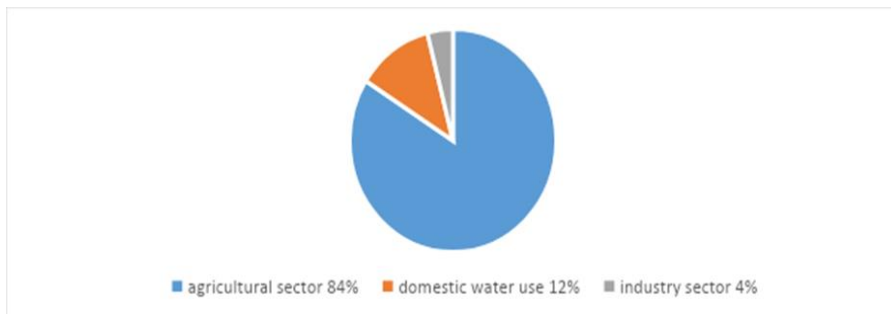


Figure (2). Percentage of water use by the agriculture, domestic, and industrial sectors

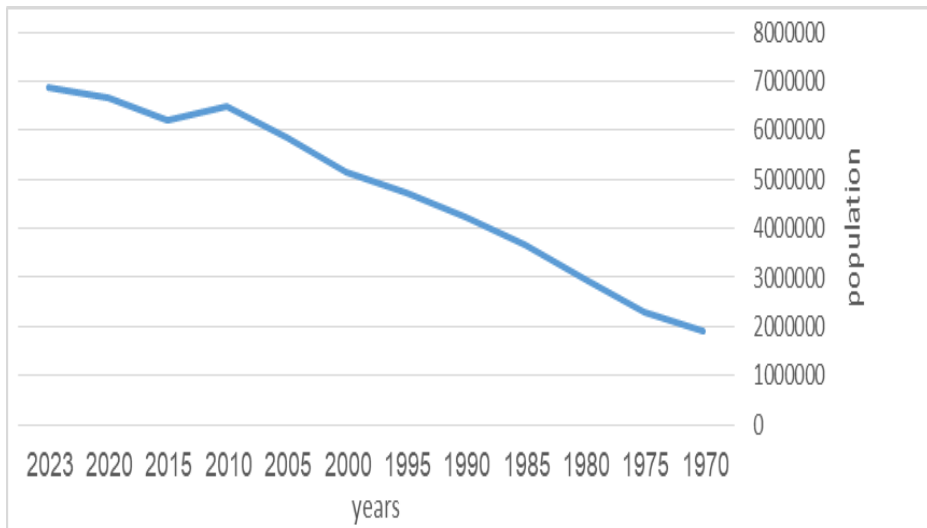


Figure (3). Population census in Libya (United Nations Population Division)

The table (2) and figure (4) below show the water situation in Libya. Based on the most recent information available to the General Authority for Water, the total need for water resources in the year 2020 is 7784 million m³, amounting to 5850 million m³ in the agricultural sector and 1512 million m³ in the drinking sector. The industry is about 422 million m³, where the deficit in water resources for the year 2020 is about 4870 million m³, and the needs for water resources in the year 2050 reach 8965 million m³, and for agriculture, 6640 million m³, for drinking, 1759 million m³, and for industry, 556 million m³, and the deficit reaches 6031 million m³.

Table 2: The water situation in Libya (1999–2025)

	Year				
	1990	2000	2010	2020	2025
Demand					
Agricultural	4275	4800	5325	5850	6640
Drinking	408	647	145	1512	1759
Industry	74	132	236	422	566
Total	4757	5579	5676	7784	8965
Climate					
Renewable water	500	500	500	500	500
Non-traditional sources	105	127	155	188	208
Made-river	-	1642	2226	2226	2226
Total	604	2269	2881	2914	2934
Deficit	4153	3310	3395	4879	6031

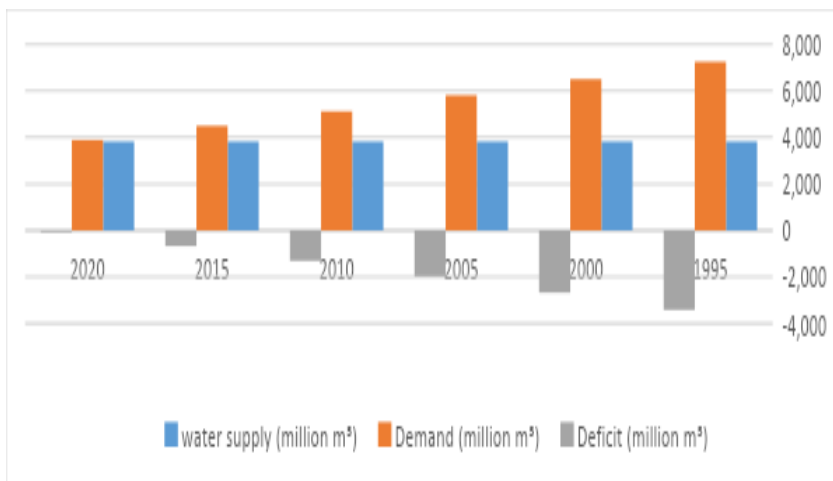


Figure (4). Water deficit in water resources in Libya

Deteriorating water quality:

With the continuous over-abstraction of groundwater resources in Libya, the water table depth is increasing, leading to an increase in the salinity and mineralization of the abstracted groundwater. Deteriorating water quality is then becoming a limiting factor for water use and eventually requires water treatment by cost-intensive technologies and disposal of brines. Due to the steady water table decrease over the last 25 years, the water quality has most likely continued to deteriorate, putting more stress on the availability of water resources (Divakar, 2020). Furthermore, untreated wastewater is disposed of in the open or in the sea, resulting in water pollution (Brika, 2019).

Challenges and Solutions

The lack of investment and maintenance is one of the major obstacles facing the Libyan hydraulic and water resources sector. The government must allocate additional funds to modernize and maintain the hydraulic infrastructure, as well as invest in the creation of new systems. Additionally, improved water resource management and governance are required to ensure their sustainable use. Utilizing modern technology such as sensors and remote sensing can aid in the monitoring and management of water

resources. In addition, the government should promote the use of alternative water sources, such as treated wastewater and rainwater harvesting, to reduce reliance on limited water resources (Abuzweda et al., 2018). The inefficient use of water in agriculture is an additional difficulty for the hydraulics and water resources sectors in Libya. The irrigation systems in Libya are inefficient and require significant enhancements to reduce water loss and enhance water distribution to farmers. The use of modern irrigation systems, such as drip irrigation, can significantly reduce water loss and increase the water use efficiency of agriculture. The government must invest in the development and implementation of these modern irrigation systems in order to increase the efficiency of agricultural water use (Zhu et al., 2021). Additionally, educating farmers on the significance of water conservation and providing them with training on modern irrigation techniques can help reduce water waste in agriculture. This can lead to a more sustainable use of water resources and improved water supply management in the country. The country's limited water resources pose one of the greatest obstacles to hydraulic and water resource management in Libya. The majority of Libya's water resources are nonrenewable aquifers, which are rapidly depleting as a result of overuse and ineffective management (Ahmed, 2003; Al-Farraj and El-Mubarak, 2012). In addition, the country's irregular rainfall patterns and arid and semi-arid climate make water resource management a complex issue. In addition to these obstacles, the Man-Made River Project (MMRP), designed to transport fresh water from the Nubian Sandstone Aquifer System in southern Libya to the coastal cities in the north, faces a number of unique obstacles. The MMRP has encountered significant obstacles, including technical difficulties with infrastructure construction and maintenance, as well as water quality and sustainability issues (Alsharif, 2008; Elhaddad and Al-Sharif, 2011; Shatwan and Al-Hamadani, 2016). There are opportunities for sustainable water management in Libya, particularly through the development of new technologies and more effective management practices, despite these obstacles. For instance, technological advancements in desalination could provide

an alternative source of water for the nation (Al-Farraj and El-Mubarak, 2012). Additionally, improved water management practices, such as improved irrigation techniques and the use of more efficient technologies, could aid in conserving the nation's limited water resources (Ahmed, 2003). Overall, the challenges facing the management of hydraulic and water resources in Libya are complex and multifaceted, requiring a variety of strategies and solutions. The academic references cited in this paper are an invaluable resource for comprehending the issues and developing evidence-based approaches to the management of water resources in Libya.

A case study of the Man-Made River

The Man-Made River Project is an example of a case study that illustrates the challenges and opportunities in hydraulic and water resource management in Libya. The MMRP was a world-leading civil engineering project when built in the 1980s, designed to transport fresh water from the Nubian Sandstone Aquifer System in southern Libya to the coastal cities of northern Libya. 80% of the population of six million lives along or near the northern Mediterranean coast and depends on fresh water pumped via its pipeline. The project consists of more than 4,000 kilometers of pipelines, wells, and pumping stations. The MMRP has the potential to provide a sustainable water source for agriculture, industry, and domestic use, thereby reducing water scarcity in coastal cities. However, the project faces a number of obstacles that threaten its viability and efficacy. Due to over-pumping and poor management, the depletion of the Nubian Sandstone Aquifer System is one of the greatest obstacles. The aquifer is a nonrenewable resource whose depletion could cause irreversible harm to the local ecosystem and socioeconomic activities. Due to the ongoing conflict and political instability in the country, the lack of maintenance and modernization of the MMRP's infrastructure is also a problem. Pipelines and pumping stations are aging and require routine maintenance and replacement, which is currently difficult to achieve. In addition, the MMRP is susceptible to sabotage and attacks, which can disrupt the water supply and have dire

repercussions, such as what usually happens in the south of Libya, where people dismantle well heads to sell the copper and close or destroy pipes to press their demands with officials in the capital (Ahmed and Ulf, 2019).

Despite these obstacles, the MMRP presents opportunities for the sustainable management of hydraulic and water resources in Libya. For example, the project can serve as a platform for promoting water efficiency, reducing water waste, and implementing innovative irrigation techniques. In addition, the MMRP can be combined with other water resource management initiatives, including groundwater management, water conservation, and rainwater harvesting. In conclusion, the Man-Made River Project is an illustration of the difficulties and opportunities associated with the management of hydraulic and water resources in Libya. The project has the potential to provide a sustainable water source for the socioeconomic development of the country, but its viability and efficacy are contingent on addressing the obstacles it faces and implementing solutions that ensure the efficient and sustainable use of water resources.

Conclusion

Water scarcity has become a major concern for many countries around the world, and Libya is no exception. The situation has been exacerbated by rapid urbanization and population growth in developing countries. This study has investigated the current situation of hydraulic and water resource management in Libya. In conclusion, the hydraulic and water resource sectors in Libya face significant obstacles due to some natural causes and human activities, such as aging infrastructure, water shortage, and ineffective administration. To ensure sustainable development and economic growth, the government and stakeholders must address these challenges immediately. It can be said that climate change is the main cause of water scarcity due to its geographical location. Lack of financial support from high authorities has been seen as another reason for water scarcity. Currently, Libya is considered inefficient in managing its water supply and resources because of

the instability of the political situation in the country. These issues have made the situation of water management resources unsustainable. Perhaps one of the critical problems that hinders sustainable water management development in Libya is the lack of renewable water resources.

Recommendations:

In light of what has been presented earlier, the researcher suggests some recommendations, as listed below:

1. Proper planning for water resources management, developing water policies, strengthening technical capabilities and national institutions, and developing mechanisms to increase transparency in public water services.
2. Preserving river water by providing regular maintenance of wells and transmission lines and protecting them from repeated attacks.
3. Empowering the Water Desalination Authority and providing it with the necessary financial and administrative support to begin maintaining its facilities and extending the scope of the facilities to areas outside the Man-Made River Project network.
4. Raising citizens' awareness about water consumption by setting water prices because free consumption in Libya, which the state supports through oil revenues, has led to citizens' indifference to water consumption.

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