Comprehensive Journal of Science
Volume (11), Issue (41), (JUNE, 2026)
ISSN: 3014-6266

مجلة العلوم الشاملة
المجلد (11) العدد 41 يونيو 2026
ردمد: 3014-6266

Sustainable Water Management and Institutional Challenges in Libya: A Groundwater Governance Perspective

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تاريخ الاستلام:2026/05/05 -تاريخ المراجعة:2026/05/28- تاريخ القبول: 2026/06/07- تاريخ للنشر: 2026 /06/21

Abstract

Due to its nearly complete reliance on non-renewable groundwater resources in an arid climate, Libya has significant issues with water sustainability. Groundwater depletion and environmental degradation are on the rise despite significant infrastructure investments like the Great Manmade River project. This study looks at Libya's sustainable water management, focusing on groundwater dependence and institutional governance. International reports, peer-reviewed articles, and hydrological assessments have all been included in a qualitative systematic literature review. The results imply that governance shortcomings, specifically institutional fragmentation, lax enforcement, and a lack of integrated water resource management, are linked to the Libyan crisis rather than actual water scarcity. The study emphasizes how fossil aquifers, like the North-West Sahara Aquifer System and the Nubian Sandstone Aquifer System, are being overused. In accordance with global sustainability frameworks like Sustainable Development Goal 6 (SDG 6), the report concludes that institutional restructuring, decentralized management, enhanced hydrological monitoring systems, and reforms to demand management are necessary for attaining long-term water sustainability.

Keywords: Groundwater governance, water scarcity, institutional fragmentation, water sustainability.

الملخص:

تواجه ليبيا مشكلات خطيرة تتعلق باستدامة المياه نتيجة اعتمادها شبه الكامل على موارد المياه الجوفية غير المتجددة في مناخ جاف. ورغم الاستثمارات الضخمة في البنية التحتية، مثل مشروع النهر الصناعي العظيم، فإن استنزاف المياه الجوفية والتدهور البيئي لا يزالان في ازدياد. تتناول هذه الدراسة الإدارة المستدامة للمياه في ليبيا، مع التركيز بشكل خاص على الحوكمة المؤسسية والاعتماد على المياه الجوفية. وقد أُجريت مراجعة منهجية نوعية للأدبيات المنشورة، شملت مقالات محكمة وتقارير دولية وتقييمات هيدرولوجية. تشير النتائج إلى أن الأزمة الليبية مرتبطة بإخفاقات الحوكمة أكثر من ارتباطها بندرة المياه الفعلية، وتحديدًا الانقسام المؤسسي، وضعف الإنفاذ، والافتقار إلى إدارة متكاملة لموارد المياه. وتُبرز الدراسة أن طبقات المياه الجوفية الأحفورية، مثل نظام طبقة الحجر الرملي النوبي ونظام طبقة شمال غرب الصحراء، تُستغل بما يتجاوز المستويات المستدامة. ويخلص التقرير إلى أن تحقيق استدامة المياه على المدى الطويل يتطلب إعادة هيكلة مؤسسية، وإدارة لامركزية، وأنظمة رصد هيدرولوجية مُحسّنة،

وإصلاحات لإدارة الطلب بما يتماشى مع أطر الاستدامة العالمية، مثل الهدف السادس من أهداف التنمية المستدامة. (ضمان توافر المياه والصرف الصحي وإدارتهما بشكل مستدام للجميع).

الكلمات المفتاحية: إدارة المياه الجوفية، ندرة المياه، الانقسام المؤسسي، ستدامة المياه.

1. Introduction

Sustainable water, as used in groundwater management, refers to the long-term conservation, equitable distribution, and efficient use of groundwater through efficient institutional, legal, and management frameworks that maintain the balance and quality of groundwater resources. This means controlling abstraction in accordance with the charging rates, preventing contamination, and enforcing licensing and monitoring procedures. This approach also emphasizes the importance of reliable data, the economic efficiency of water use, social equity in access, and stakeholder participation in the decision-making process. Sustainable groundwater management eventually incorporates hydrological, institutional, and socioeconomic factors to ensure resilience, protect resources, and ensure water availability for current and future generations.

The scarcity of water in Libya is one of the most significant environmental and governance concerns in North Africa. The nation is situated in an arid to semi-arid climate with little surface water and precipitation. Because of this, groundwater is the nation's main and nearly exclusive source of fresh water, accounting for over 90% of all water consumption.

Libya is essential for its extensive fossil aquifer systems, including the Nubian sandstone aquifer system (NSAS), the North West Sahara aquifer system (NWSAS), the Jifarah Plain aquifer, and the Murzuq Basin. Because these aquifers were formed under paleoclimatic conditions and have a very low or nonexistent recharge rate, they are essentially non-renewable in human timescales. The NSAS and NWSAS are cross-border aquifer systems, so sustainable management calls for coordinated regional management.

The Great Manmade River project significantly increased the amount of water available to coastal cities by pumping fossil groundwater from the southern regions, but it did not address the more basic institutional and management problems with water. Rather, rising water abstraction has put more strain on aquifers, especially in coastal and agricultural regions. According to recent research, Libya's water crisis is more of an institutional and governance failure than a physical shortage issue, with fragmented decision-making, lax enforcement, and a lack of integrated planning dominating water management (Hamad, 2019).

Literature Review

International research on water management in arid regions indicates that groundwater governance is a crucial element of sustainability, particularly in fossil aquifer systems with limited recharge. Groundwater is the basis of Libya's national water supply systems, despite the fact that desalination and wastewater reuse are still underdeveloped supplemental sources (Al-Barghouti, 2024). Hydrogeological research indicates that Libya's primary aquifers, particularly the NSAS and NWSAS, are large transboundary fossil groundwater systems with very low recharge rates and long residence times, making them highly susceptible to overexploitation (Hamad, 2019). The aquifers in the Murzuq Basin and Jifarah Plain are also being strained more by the expansion of agriculture and urban water demand.

Since many ministries and agencies share water responsibilities with little coordination, overlapping mandates, poor policy implementation, and weak accountability structures, institutional fragmentation may be the biggest obstacle to the sustainable management of water resources from a governance perspective (Rashed, 2013). Furthermore, research indicates that Libya has not yet fully embraced the internationally recognized framework for sustainable water governance, IWRM, because of institutional weakness, political unpredictability, and the absence of a hydrological data system (Wheida, 2012). Additionally, environmental studies show that unsustainable groundwater extraction has resulted in declining water tables, seawater seeping into coastal aquifers, and deteriorating groundwater quality, particularly in the Jifarah Plain where intensive agricultural pumping has exceeded sustainable limits (Hamad et al., 2017).

Methodology

This study uses a qualitative approach to conduct a systematic review of the literature. Information was gathered from international organizations, institutional reports, and peer-reviewed publications that were released between 2010 and 2025. Groundwater availability, institutional governance, policy frameworks, and environmental degradation were the main topics of the analysis, which employed a thematic synthesis method. This approach is suitable for Libya because of the dearth of field data, disjointed hydrological monitoring systems, and political unrest that prevent thorough empirical data collection. Hydrogeological and management viewpoints can be combined into a single analytical framework thanks to this synthesis.

Results and Discussion

According to the analysis, nearly all of Libya's water supply comes from fossil groundwater aquifers, making the situation structurally unsustainable because of extraction rates that significantly exceed natural replenishment. This is particularly evident in large systems like the North Western Sahara Aquifer System and the Nubian Sandstone Aquifer System, where there is little recharge and an increasing demand for water due to urbanization and agriculture (Hamad, 2019). As a result, the current patterns of consumption cannot be maintained without seriously depleting essential groundwater reserves, and the long-term security of water resources is essentially limited.

At the institutional level, the water sector's governance is characterized by fragmented structures with multiple governmental bodies operating with redundant responsibilities and poor coordination. Ineffective water management techniques are the end result of this division, which also leads to redundant roles, uneven policy implementation, and decreased accountability. Furthermore, the situation is made worse by the lack of integrated decision-making processes since sector-specific methods predominate in resource allocation and policy enforcement (Rashed, 2013). It is commonly known that these governance flaws are the main cause of Libya's unsustainable water use.

There is a notable disparity between infrastructure development and governance capacity in addition to institutional difficulties. Libya has invested heavily in hydraulic infrastructure, especially through the Great Man-Made River project, but the institutional frameworks needed for efficient operation, maintenance, and monitoring have not advanced to a comparable degree.

The overall efficacy of water supply systems has been limited as a result of this discrepancy, which has led to decreased operational efficiency, increased system losses, and vulnerability to technical failures (Wheida, 2012). In addition to institutional difficulties, there is a significant gap between the development of infrastructure and the capacities of governance. Libya has made substantial investments in hydraulic infrastructure, particularly through the Great Man-Made River project, but the institutional frameworks required for efficient operation, monitoring, and maintenance have not advanced at the same rate. The overall performance of water supply systems has been hampered by this gap, which has resulted in decreased operational efficiency, increased system losses, and vulnerability to technical issues (MDPI, 2018).

Overall, the findings indicate that the primary cause of Libya's water crisis is not resources but rather the government. Sustainable management efforts are severely hampered by

inadequate data integration, lax enforcement of regulations, and poor institutional coordination, despite the country's substantial groundwater supplies. These governance-related constraints hinder the water sector's capacity to adjust to growing demand and environmental demands, perpetuating a cycle of over-extraction and resource degradation (Al-Barghouti, 2024).

Institutional and Policy Implications

The institutional structure of Libya's water sector needs to be drastically altered. The absence of a single national water authority leads to weak regulatory control and distributed decision-making. Financial constraints and insufficient technical capabilities further hinder effective water governance. Additionally, the lack of reliable hydrological data systems impedes evidence-based planning and adaptive management (Rashed, 2013).

Challenge	Description	Impact
Institutional fragmentation	Multiple agencies with overlapping responsibilities	Inefficient governance
Weak enforcement	Limited regulatory compliance	Over-extraction
Centralized governance	Limited regional autonomy	Delayed decisions
Financial constraints	Insufficient funding	Infrastructure deterioration
Data limitations	Weak monitoring systems	Poor planning

Table 1: Institutional Challenges in Libya's Water Sector.

Conceptual Framework

According to the conceptual model, groundwater abstraction is impacted by institutional fragmentation and lax regulatory enforcement in a governance--resource feedback loop. Over-extraction depletes aquifers and deteriorates the environment, further taxing already fragile governance frameworks. This cycle highlights the need for coordinated government reform and flexible water management strategies.

Recommendations

Libya's issues with water sustainability are mostly due to institutional and governance shortcomings rather than a total lack of water. Despite the country's substantial fossil groundwater reserves, unsustainable abstraction and fragmented governance frameworks pose a threat to long-term water security. To address these issues, integrated institutional transformation, improved coordination mechanisms, and the adoption of international water governance frameworks like IWRM are all required. In the absence of such actions, ongoing

groundwater depletion will gravely endanger economic expansion, environmental stability, and national resilience.

Conclusion

For institutional restructuring to accomplish sustainable water management in Libya, a centralized but functionally integrated national water authority must be established. Implementing integrated water resources management is necessary to ensure sustainable resource allocation and align sectoral planning.

Hydrological monitoring systems must be updated with digital technology and remote sensing methods to improve data availability. Groundwater abstraction must be regulated by legally binding frameworks, and modern irrigation techniques should increase the effectiveness of agricultural water use. At the national and regional levels, institutional strengthening and capacity building are also essential to improving the effectiveness of governance.

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