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Assessment of Unconventional Water Harvesting Techniques to Address Climate Challenges in Some North African and Middle Eastern Countries

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Abstract

This study focuses on unconventional water harvesting techniques in five countries that suffer from water scarcity: Egypt, Ethiopia, Jordan Libya, and Sudan. Unconventional techniques have presented a very good paradigm with which to respond to environmental and economic challenges; thus, they have been classified as innovative and traditional methods. MOFs Metal-Organic Frameworks-based newly developed methodologies were able to extract approximately 2.4 liters per day in Jordan. An atmospheric state provides daily intakes between 10-500 liters brought by the fog nets. Surface water harvesting methods like earth ponds and sand dams supply between 1,000 and 5,000 liters per day in Egypt. Libya gets an adequate daily intake of up to 525,680,000 liters from desalination since it heavily depends on this particular method for its water needs. It produces between 50 and 200 liters per day through urban rooftop rainwater harvesting.The results of this study emphasize that Additional benefits from applying techniques that are considered traditional along with modern technologies are achieved when they work together to provide water security and responses to climate change. Sustainability initiatives will include improvements in current water management methods, and increasing investment in research and development, all leading to the ability to meet the increasing demand for water within the communities.

Keywords: Unconventional Water Harvesting, Water Scarcity, Water Management, Water harvesting, North Africa , Middle East

I. Introduction

There are several different types of Water Harvesting Techniques that can be used in drought-stricken regions to create a sustainable source of Water to meet the growing need for water resources(Kinzelbach et al., 2010). They can be categorized into two primary categories: Traditional technologies rely on collecting rainwater, directing surface runoff, and storing it in reservoirs or behind dams; while modern technologies utilize advanced technological means to extract water from atmospheric sources such as fog condensation and moisture extraction from the air(Ahmed et al., 2023). Fog Nets and Dew Collectors), and modern techniques developed specifically for extracting Water from Atmospheric, Surface and Ground Water. Such Water Harvesting Techniques can have varying levels of effectiveness and scalability; as such, the success of a specific Water Harvesting Technique will depend on several factors that are specific to the location in which it is implemented (Natural, Social and Economic) For example, the Atmospheric Water Harvesting Techniques of Fog Nets and Dew Collectors are utilized in locations with high relative humidity and/or frequent fog. Fog Nets have been shown to successfully capture Drinking Water, with collections between 10-500 L/day, typical of those in the Afar Region of Ethiopia(Qadir et al., 2021). A recent example of

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Atmospheric Water Harvesting Technique is the Metal Organic Frameworks (MOFs), developed in Jordan(Al-Addous et al., 2023). MOFs are suitable for application in urban areas with limited water resources since MOF-801 allows water to be extracted from atmospheric humidity at a rate of 2.4 L/kg. However, the Utility of MOFs is significantly impacted by Environmental Conditions, and there is a need to develop and maintain Infrastructure to ensure their continued effectiveness(Al-Addous et al., 2023; Wang et al., 2022). For ages, people have collected and stored surface water for use by humans and agriculture in arid areas using traditional methods like sand dams and earth ponds, sometimes known as micro-dam(Ritchie et al., 2021).Rainwater and other precipitation can be collected and stored for use in various regions of Africa using a variety of techniques. For example, in the Nile Delta region of Egypt(Abd-Elhamid et al., 2018). earthen ponds can hold an average of 1000-5000 litres of water each day from intermittent rainfall events to provide irrigation resources needed to sustain agriculture in this areav(Wang et al., 2022). In Sudan, sand dams are an economical means of storing rainwater at between 600-1800 litres per day, with low maintenance requirements. Rainwater collection from rooftops provides the ability to capture rainwater from urban and rural locations for use in Addis Ababa and Cairo, with an estimated average output of 50-200 litres of collected rainwater per day. The efficiency of this method is limited by rainfall amounts during dry periods(Oweis & Hachum, 2006).

Groundwater is another way to collect and store water from below the ground surface for later use when needed, with an average daily yield of 4050 litres(Mohamed, 2019). Groundwater is a critical source of water for resupplying the water table and replenishing aquifers throughout the Amhara region of Ethiopia. Libya relies on the ever-increasing use of desalination technologies to meet its immense demands for high-quality drinking water due to limited availability of freshwater resources provided naturally by the environment(Brika, 2018). Desalination processes consume a lot of energy and require large capital investments, making them less effective for meeting water demand in remote areas. Wastewater treatment in Libya involves treating large volumes of wastewater for reuse in agriculture and urban areas to increase water security while alleviating the over-extraction of the limited available freshwater resources(Almassad et al., 2022a; Brika, 2019). The integration of traditional techniques with modern technology is effective in enhancing water security, especially in areas experiencing climate change and increasing water demand(Mashudi et al., 2023). This study focuses on evaluating the feasibility of employing a range of non-conventional techniques for abstracting water resources from diverse sources to meet agricultural needs and human consumption in arid and semi-arid regions. The research specifically examines the efficiency of using Metal-Organic Frameworks (MOF-801), rainwater harvesting systems, reverse osmosis desalination technologies for seawater, in addition to leveraging soil as a moisture reservoir, and artificial river projects(Zhang et al., 2022). The study further seeks to analyze the environmental and economic impacts resulting from these methods to ensure their sustainability and effectiveness across five countries: Egypt, Ethiopia, Jordan, Libya, and Sudan. This includes assessing the compatibility of these solutions with local requirements and population needs, ultimately providing systematic recommendations aimed at enhancing the integration of modern techniques with traditional practices; thus ensuring increased efficiency in water resource management and developing their capacity for expansion and adaptation across varied geographical environments(Mohamed, 2019).

II. Materials and Methods

Study Area

This study is designed to address the systemic water scarcity challenges inherent in regions characterized by extreme aridity and semi-arid environments. This study will examine five countries (Egypt, Ethiopia, Jordan, Libya, and Sudan) in detail. Each area has developed various methods of collecting rainwater based on many factors including geographic features, environmental features, and social and economic characteristics. For instance:

• During the summer months, Egypt depends heavily on the Nile River as its main source of water. To maximize the use of this water source, Egypt uses surface water harvesting systems.

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• Jordan predominantly uses modern methodologies to collect atmospheric precipitation with a focus on developing metals-organic frameworks to create an atmosphere for resourcing.

• Ethiopia and Sudan both have varying elevations within the country, but use similar methods like fog nets and sand dams to collect rainwater and establish groundwater extraction systems.

• Libya is an arid region (i.e., coastal area) and so has invested heavily in desalination plants and the treatment of reclaimed wastewater.

III. Collection

Data were obtained for this study from various published sources including research articles, published reports and published case studies, pertaining to the different types of water harvesting devices that have been used in each of these regions. The literature was collected from a variety of miscellaneous scientific databases and reputable indexed journals including for the years 2006-2020, which resulted in an extensive body of knowledge including the following:

1. A detailed analysis of each of the 5 countries was completed for the purpose ofevaluating how effective their own technology is, in light of both their environmental weather patterns, the population needs of the area and any geographical limitations they may be faced with.
2. An in-depth study was performed of both cutting-edge technology as well astraditional water harvesting technologies to include: water harvesting from MOF's, fog nets, dew collectors, earth ponds, sand damns, rooftop rain gutter systems, and waste-water treatment systems.
3. The amount of water collected by each technology type was documented andincluded both the amount of water, as well as average daily amount collected from the different types, with fog nets collecting an average of 10 to 500 L per day, along with advanced WWTS types that can produce anywhere from 525,680,000 L per day in Libya.
4. The types of both consumable and agricultural use of these different technologiesshow that these technologies can be employed at each site.
5. Specific examples were compiled for how each type of technology was implemented across each of the 5 countries and additional examples of use at several sites across the world.

Methods

To evaluate the efficiency and versatility of water harvesting methods between different countries, this research used a comparative analytical approach. To do this, the researchers created a number of steps as outlined below:

A) As a first step in evaluating the effectiveness of each system and its adapt-ability, the researchers grouped each of the water-harvesting techniques into one or more general categories. For example, all atmospheric water-harvesting systems were grouped together, while all surface water-harvesting systems were grouped together, and all groundwater-harvesting systems were grouped together.

B) In addition to identifying water-harvesting techniques, the researchers identifieddesalination and wastewater treatment as types of ”nontraditional” or unconventional water supply sources.

C) The researchers also established their Key Performance Indicators (KPIs).These KPIs include how many litres of water were produced from each waterharvesting technique, and whether the water produced was intended for human or agricultural use, how much maintenance was required for that particular system, how much was spent on operating that system, and how sustainable that system was for the environment.

D) After establishing KPIs for each water-harvesting technique, the researchers then ran a statistical analysis(Two-way ANOVA analysis) on their collected data and were able to measure the effectiveness of each water-harvesting system in solving water scarcity issues by using SPSS statistical software. Graphs and Charts were created to easily compare the various methods(Al-Daraji et al., 2026).

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IV. Results and Discussion

Unconventional Water Supply Technology

As demonstrated by Table 1, there is a wide range of technology used in countries with limited freshwater supply and dry climate. The MOF-801 technology is an example of a nontraditional form of water collection by extracting moisture from the ambient air. MOFs operate well under low humidity levels and provide viable drinking water in such drier desert areas where there are no available sources of freshwater (i.e. Jordan) (Al-Addous et al., 2023); therefore, MOF-801 technology is a viable means to provide for basic human needs to remote communities lacking any other options of accessing potable water(Almassad et al., 2022a). In summary, MOF-801 technology has potential to help meet the basic human needs of those communities that have very few means to access potable water; MOF-801 consequently would be a viable alternative for these same communities. The alternative ways of collecting and treating water would require extensive more capital investment and/or require extensive amounts of time to implement. Libya's Great Man-Made River Project is one of the largest non-renewable groundwater projects and aims to move water from the country's southern aquifers supplying large amounts of water to the northern parts of Libya where there are extreme deficiencies of water resources. Approximately 600,000 litres of water is supplied each day utilising various types of very large scale infrastructure, which means that the infrastructure needs ongoing maintenance to address the problems associated with the depletion of groundwater and also to meet the needs resulting from a growing thirst for groundwater. Although the project is viewed as a temporary solution, it has created an opportunity for the growth of sustainable technology as a result of the limited non-renewable resources(Almassad et al., 2022b). Egypt is facing major challenges with respect to water resources and has begun to implement non-conventional technology including rainwater collection and artificial surface water storage in order to address them since it is nearly completely dependent upon the Nile River as a water source. As part of its efforts to conserve water, Egypt has begun to implement the use of rainwater storage and construct sand dams in order to enhance water resource efficiency on its desert soils in the Sinai Peninsula(Ezzeldin, 2021). The coastal and urban regions of Egypt are using desalination technology in order to increase their water supply security through the addition of new water sources. Ethiopia and Sudan are also facing serious water shortages and have begun to turn to non-conventional technologies to mitigate their immediate crises(Tolossa et al., 2020). Rainwater harvesting technology in Ethiopia is utilized at the rural level as well as the urban centralised level of the country's capital city of Addis Ababa, where rainwater is stored for use up to 200 litres/day per unit. This method of collecting rainwater provides a means of effectively storing rainwater to reduce pressure on other traditional sources of water(Adugna et al., 2018). Additionally, Ethiopia depends on the technical process used in drilling

Table 1 The country in which the technique was applied

Technology Type	The Country Applied
MOF-801	Jordan
Surface Water Storage	Egypt
Atmospheric Water Harvesting	–
Surface Water Harvesting	–
Rainwater Harvesting	–
Subsurface Water Harvesting	–
Surface Water Storage	Ethiopia
Atmospheric Water Harvesting	–
Surface Water Harvesting	–
Rainwater Harvesting	–
Subsurface Water Harvesting	–
Groundwater Recharge	–
Non-conventional water resources	Libya
Rainwater harvesting	–

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Non-conventional water resources	–
Surface Water Storage	Sudan
Atmospheric Water Harvesting	–
Surface Water Harvesting	–
Rainwater Harvesting	–
Subsurface Water Harvesting	–

groundwater wells, used for drinking and irrigation purposes. However, there are issues regarding water quality and possible contamination associated with this method of providing water to the population(Pareta et al., 2024).

Frequency and Distribution of Unconventional Water Harvesting Technologies

The visual at Figure 1 demonstrates a considerable transformation of the frequency of the use of non-conventional methods of water harvesting from 2006 to 2020. The period of highest utilisation of these methods is observed between 2012 and 2016 due to the escalating worldwide water crisis and localised demands creating the need for the development of innovative, new technical solutions by governments. Thus, the changing level of usage for these technologies demonstrates a response to the continuously increasing requirements for effective methods for sustaining supplies of drinking water and eventually satisfying the demands of people who reside in urban and rural communities within the countries identified above that have limited supplies of water (Dashkevych & Housh, 2025).

One of the technologies that have consistently been utilised from2010 onwards, is desalination of water, which is viewed as strategically beneficial for coastal areas of the countries of Libya and Egypt because it converts saline water into drinking and

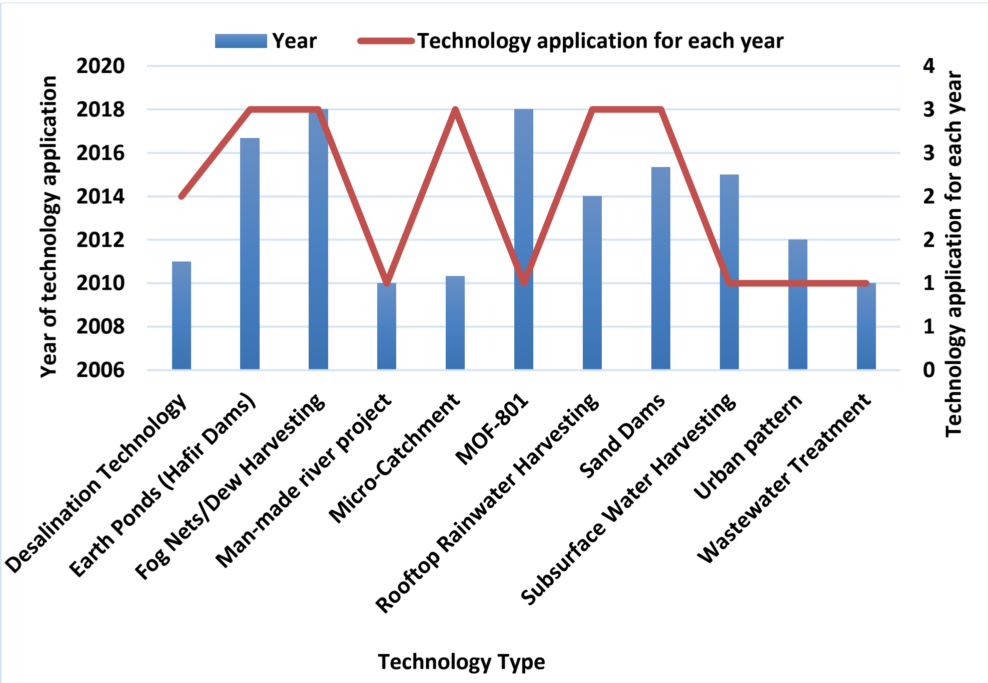

Fig. 1 Year of Technology Application and Technology Type

agricultural water. There has also been a substantial increase in the number of applications for rainwater harvesting techniques in Egypt, whereby considerable usage has occurred in urban settings because of the

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extensive land surfaces available for rainwater collection and storage. Collected rainwater is typically utilized for irrigation of smaller agricultural parcels or household purposes, in order to reduce the stress on traditional water sources(Salih, 2018). Post-2018, such a trend towards lower rates of new technology adoption can be attributed to a shift in interest toward improving system operation and maintenance rather than investing in new technologies. The hafir basin system used in Sudan, for example, is subject to regular maintenance to ensure year-round use(Castelli et al., 2022). Computing support has focused increasingly on increasing the efficiency of maintenance and operation for existing systems as opposed to investing in new technologies, as this provides an equilibrium between available resources and practical demand for capabilities, thus supporting the ongoing resource sustainability and directing funds towards optimal operational performance and continued regular maintenance of all systems being maintained.

Capabilities of Unconventional Water Technologies and Their Diverse Applications

The ability to utilize unconventional water technologies varies, as shown in Table 2, which provides an example of how each country uses these technologies differently. Desalination technology is utilized in Libya at a very high production rate of as much as 525,000 L/Day. Desalination technology will provide potable and household water for Libyans, particularly those living along the coast, where seawater is available. Although there are considerable costs involved with the use of desalination, as well as the energy needed to operate this equipment, it will be necessary to provide safe, sustainable, and adequate water supplies for urban areas that are densely populated(Brika, 2018; Elhajaji et al., 2014) The Hafir Dams are an important method of collecting and storing surface

Table 2 The Capacity of Unconventional Water Technologies and Their Applications

Technology Type	**Volume of water supplied by technology (L.day^{-1})**		
	Mean	**Minimum**	**Maximum**
Desalination Technology	262595.89	191.78	525000.00
Earth Ponds (Hafir Dams)	2583.33	2000.00	3000.00
Fog Nets/Dew Harvesting	52.50	50.00	55.00
Man-made river project	600000.00	600000.00	600000.00
Micro-Catchment	325.00	300.00	375.00
MOF-801	2.4000	2.40	2.40
Rooftop Rainwater Harvesting	218.33	175.00	305.00
Sand Dams	1183.33	1000.00	1300.00
Subsurface Water Harvesting	4050.00	4050.00	4050.00
Urban pattern	92000.00	92000.00	92000.00
Wastewater Treatment	1458000.00	1458000.00	1458000.00

water in Sudan. The Hafir Dam has a variety of uses, including the storage and collection of water for irrigation during the dry season, where the need for agriculture is greatest in many rural communities. These dams accumulate water during the rainy season, allowing it to be used during drought periods. Although inexpensive, Hafir Dams require ongoing maintenance and care to avoid sedimentation build up(Sunkemo, 2022). Fog nets collect water from fog (50 to 55 liters per day), offering a low-cost option in many poorer areas like Sudan and Ethiopia where there are often large quantities of moisture in the atmosphere. This is an effective way of providing water in places that frequently experience fog conditions at little or no cost and thus are useful for rural and mountainous areas(Almassad et al., 2022b). On rooftops in Egypt, Rainwater Harvesting Technology has been used very successfully in urban areas such as Cairo where the demand for water is high. The ability to effectively capture then store rainwater allows for its use during extended dry periods and better equips those wishing to grow crops or maintain livestock and provides a low-cost option for both indoor and agricultural use. Finally, many people in smaller communities utilize surface storage techniques to prepare for dry periods such as building small dams or basins in order for them to store water runoff in waterways such as the Nile Delta contributing to improved irrigation (Gado & El-Agha, 2020).

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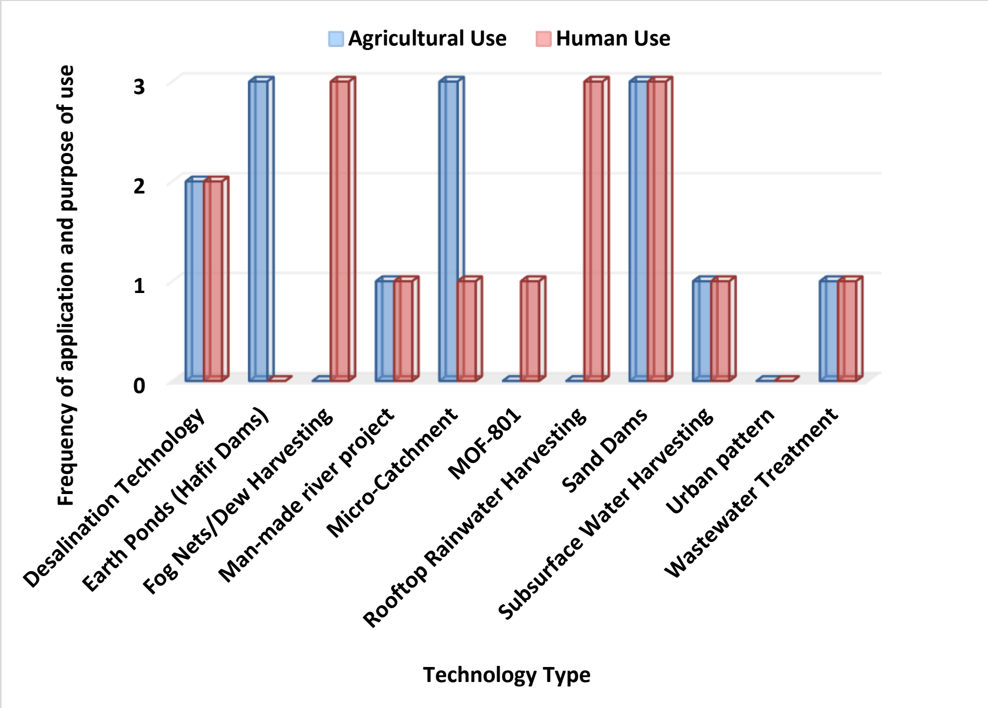

Fig. 2 Frequency of application and purpose of use and Technology Type

Effective Use of Unconventional Water Harvesting Technologies

The usage of various types of unconventional methods for harvesting rainwater for both personal and agricultural use depicted in Figure 2 show the differences in the way each of the participating countries are utilising these types of methods to meet the water needs of both agriculture and other uses by the differing levels of demographic, Environmental and Technological(Castelli et al., 2022). The types of Technologies being utilised highlight the impact that these technologies are having on the respective Region's Water Management System and how each of these Systems has been tailored to each country, in particular, Egypt, Sudan, Libya, Ethiopia, Jordan and others have applied these technologies in addressing their country's specific Climatic, Water Management, Infrastructure, and Economic needs The technologies can be classified on the basis of their primary purpose as follows::

Agricultural Technologies

Surface Water Storage and Sand Dams Are Mainly Used For Agricultural Irrigation.to Make Available Large Quantities Of Stored Water That Can Be Used During Periods Of Low Rainfall, for example, the application of surface water storage and sand dams as a solution for agricultural irrigation in Egypt, Sudan And Ethiopia (Oweis & Hachum, 2006). The Use Of Surface Water Storage As The Primary Source For Agricultural Irrigation Was Created Due To The Need For A Source Of Water Depending On Seasonal Rainfall. Surface Water Storage Is Flexible Due To The Vast Amount Of Water (Surface Water)

Available For Storage And The Increased Rate Of Evaporation During Periods Of Low Rainfall. An Example Of A Type Of Surface Water Storage Technology Is Sand Dams; Sand Dams Are Used To Prevent Evaporation And Pollution That May Occur In Areas Where There Is Varying Rainfall (i.e. Sudan And Ethiopia) Supporting Agricultural Production (Papa & Frappart, 2021).

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Technologies for Human Use

Any Form Of Water Harvesting Through Dew Is Based Upon Specific Climatic Conditions And Advanced Technologies, For Example Dew Harvesting Technology Used To Provide Potable Water [Drinking Water] To Coastal Villages Along The Red Sea in Egypt And Egypt, However, Does Not Support Agricultural Irrigation. By Contrast, Desalination Provides Drinking Water [Potable Water] In Libya, As Coastal Cities Use Desalination to Support Drinking Water Needs, Though Desalination Uses Large Amounts Of Energy (Xu & Yaghi, 2020).

Multipurpose Technologies

Many different types of projects can be classified as ”industrial rivers,” or projects that utilize unconventional sources of water for multiple purposes, including agricultural and human activities (as seen in Libya). The Great Man-Made River (GMR) Project is recognised as one of the largest industrial river projects in the world, taking water from extensive underground aquifers to fulfil the water needs of cities and agricultural regions in Libya. The GMR Project is also increasing water security in a country where there is limited availability of renewable water resources(Sadeg & Al-samarrai, 2020).

V. Conclusion

1. Variety in Technologies for Supplying Water: A diversity of technologies, includingthe MOF-801 technology in Jordan and the Great Man-Made River project in Libya (these examples illustrate the adaptation of these technologies to local conditions to overcome challenges associated with providing potable water).
2. Desalination and Water Storage Remain Critical: Desalination has become anintegral part of ensuring potable water for countries such as Egypt and Libya. Storage methods, including Hafir dams located in Sudan, allow those countries to preserve water during periods of drought.
3. Catching Rainwater as an Alternative Resource: Harvesting rainwater is a viablemethod to mitigate demands on traditional water supply systems, particularly in urban settings such as Cairo where rainwater harvesting systems improve the sustainability of water use.
4. Focusing on the Efficiency of Existing Technologies: The decline in the implementation of new technologies following 2018 suggests a modification in approach. Rather than create new technology for water supply, there is an increased focus on the effective maintenance of existing infrastructure and improving its operational efficiency to ensure greater sustainability.

VI. Recommendations.

1. Increasing Research and Development: Using Government Funding to Support Innovation through Funding for Companies Using Non-Traditional Methods of Water Management, such as Desalination & Rain Harvesting, Will Enhance Their Ability to Meet Community Needs by Making Them More Efficient & Have More Capacity.

2. Establish Integrated Water Management Policies: Comprehensive Water Management Policy Should Be Established, Drawn from Accurate Sufficient Data to Ensure the Enforcement of Community Awareness of the Need to Conserve Water through Improved Distribution of Water After Installation of Rainwater Harvesting Technology to Improve Water Distribution Infrastructure; Both of These Programs Will Guide the Development of Comprehensive Water Management Policies.
3. Increase Regional Cooperation: Countries in the Region (e.g., Egypt, Libya,Sudan Ethiopia) Will Establish Partnerships with Each Other to Share Knowledge and Experiences Related to Water Management as a Means to Work Together to Develop Joint Solutions Create Sustainable Water Resources.

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Declarations

- Funding

No funding was received for conducting this study.

- Conflict of interest

The authors declare that they have no known financial or non-financial conflicts of interest that could influence the work described in this paper.

- Author contribution

The authors contributed equally to this work

VII. References

Abd-Elhamid, H. F., Abd-Elaty, I., & Negm, A. M. (2018). *Control of Saltwater Intrusion in Coastal Aquifers* (pp. 355–384). https://doi.org/10.1007/698_2017_138

Adugna, D., Jensen, M., Lemma, B., & Gebrie, G. (2018). Assessing the Potential for Rooftop Rainwater Harvesting from Large Public Institutions. *International Journal of Environmental Research and Public Health*, *15*(2), 336. https://doi.org/10.3390/ijerph15020336

Ahmed, S., Jesson, M., & Sharifi, S. (2023). Selection Frameworks for Potential Rainwater Harvesting Sites in Arid and Semi-Arid Regions: A Systematic Literature Review. *Water*, *15*(15), 2782. https://doi.org/10.3390/w15152782

Al-Addous, M., Bdour, M., Alnaief, M., Rabaiah, S., & Schweimanns, N. (2023). Water Resources in Jordan: A Review of Current Challenges and Future Opportunities. *Water (Switzerland)*, *15*(21). https://doi.org/10.3390/w15213729

Al-Daraji, F. K., Abdulaali, H. H., Al-Jorani, Y. S. J., & Albehadili, M. H. M. (2026). Modelling Hydrodynamic Changes in the Salinity of the Hammar Marsh and Shatt al-Arab Waters Using Dimensional Analysis and Remote Sensing. *Pakistan Journal of Agricultural Research*, *39*(1). https://doi.org/10.17582/journal.pjar/2026/39.1.203.214

Almassad, H. A., Abaza, R. I., Siwwan, L., Al-Maythalony, B., & Cordova, K. E. (2022a). Environmentally adaptive MOF-based device enables continuous self-optimizing atmospheric water harvesting. *Nature Communications*, *13*(1). https://doi.org/10.1038/s41467-022-32642-0

Almassad, H. A., Abaza, R. I., Siwwan, L., Al-Maythalony, B., & Cordova, K. E. (2022b). Environmentally adaptive MOF-based device enables continuous self-optimizing atmospheric water harvesting. *Nature Communications*, *13*(1), 4873. https://doi.org/10.1038/s41467-022-32642-0

Brika, B. (2018). Water Resources and Desalination in Libya: A Review. *EWaS3*, 586. https://doi.org/10.3390/proceedings2110586

Brika, B. (2019). The water crisis in Libya: causes, consequences and potential solutions. *Desalination and Water Treatment*, *167*(June 2018), 351–358. https://doi.org/10.5004/dwt.2019.24592

Castelli, G., Piemontese, L., Quinn, R., Aerts, J., Elsner, P., Ertsen, M., Hussey, S., Filho, W. L., Limones, N., Mpofu, B., Neufeld, D. G., Ngugi, K., Ngwenya, N., Parker, A., Ryan, C., de Trincheria, J., Villani, L., Eisma, J., & Bresci, E. (2022). Sand dams for sustainable water management: Challenges and future opportunities. In *Science of the Total Environment* (Vol. 838). https://doi.org/10.1016/j.scitotenv.2022.156126

Dashkevych, O., & Housh, M. (2025). Management of Conventional and Non-Conventional Water Sources: A Systematic Literature Review. *Water*, *17*(20), 3006. https://doi.org/10.3390/w17203006

Elhajaji, A., Al Khaddar, R., Dürr, S., & Haddoud, D. (2014). Thermal Desalination Technologies as Alternative Options for Water Scarcity in Libya. *World Environmental and Water Resources Congress 2014*, 2247–2258. https://doi.org/10.1061/9780784413548.224

Ezzeldin, M. (2021). Challenges of water resources management in Egypt and solution opportunities. *Stroitel'stvo: Nauka i Obrazovanie [Construction: Science and Education]*, *11*(1), 1–14. https://doi.org/10.22227/2305-5502.2021.1.1

Gado, T. A., & El-Agha, D. E. (2020). Feasibility of rainwater harvesting for sustainable water management in urban areas of Egypt. *Environmental Science and Pollution Research*, *27*(26), 32304–32317. https://doi.org/10.1007/s11356-019-06529-5

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 15, Issue 1 (2026) PP 196-205
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/m2kjyh17

Kinzelbach, W., Brunner, P., von Boetticher, A., Kgotlhang, L., & Milzow, C. (2010). Sustainable water management in arid and semi-arid regions. In *Groundwater Modelling in Arid and Semi-Arid Areas* (Vol. 9780521111294, pp. 119–130). Cambridge University Press. https://doi.org/10.1017/CBO9780511760280.009

Mashudi, Sulistiowati, R., Handoyo, S., Mulyandari, E., & Hamzah, N. (2023). Innovative Strategies and Technologies in Waste Management in the Modern Era Integration of Sustainable Principles, Resource Efficiency, and Environmental Impact. *International Journal of Science and Society*, *5*(4), 87–100. https://doi.org/10.54783/ijsoc.v5i4.767

Mohamed, N. N. (2019). Negative Impacts of Egyptian High Aswan Dam : Lessons for Ethiopia and Sudan. *International Journal of Development Research*, *09*(08), 28861–28874.

Oweis, T., & Hachum, A. (2006). Water harvesting and supplemental irrigation for improved water productivity of dry farming systems in West Asia and North Africa. *Agricultural Water Management*, *80*(1-3 SPEC. ISS.), 57–73. https://doi.org/10.1016/j.agwat.2005.07.004

Papa, F., & Frappart, F. (2021). Surface Water Storage in Rivers and Wetlands Derived from Satellite Observations: A Review of Current Advances and Future Opportunities for Hydrological Sciences. *Remote Sensing*, *13*(20), 4162. https://doi.org/10.3390/rs13204162

Pareta, K., Karan, S., Enemark, T., Reddy, T., Dashora, Y., Issar, T., & Jensen, K. H. (2024). Groundwater quality assessment for drinking and irrigation purposes in the Ayad river basin, Udaipur (India). *Groundwater for Sustainable Development*, *27*, 101351. https://doi.org/10.1016/j.gsd.2024.101351

Qadir, M., Jiménez, G. C., Farnum, R. L., & Trautwein, P. (2021). Research History and Functional Systems of Fog Water Harvesting. *Frontiers in Water*, *3*(April), 1–11. https://doi.org/10.3389/frwa.2021.675269

Ritchie, H., Eisma, J. A., & Parker, A. (2021). Sand Dams as a Potential Solution to Rural Water Security in Drylands: Existing Research and Future Opportunities. *Frontiers in Water*, *3*. https://doi.org/10.3389/frwa.2021.651954

Sadeg, S. A., & Al-samarrai, K. (2020). *Libya Water file (DRAFT) Libya water file (Draft) prepared to FANACK Water June , 2020 Libya*. (April). https://doi.org/10.13140/RG.2.2.30225.40802

Salih, A. (2018). *Water Harvesting Symposium Title : Water Harvesting Practices and Techniques Used in Sensing and GIS Researchers :* (September 2016).

Sunkemo, A. (2022). Exploring factors that affect adoption of storage-based rainwater harvesting technologies: The case of Silte Zone, Southern Ethiopia. *Proceedings of the International Academy of Ecology …*, *12*(3), 144–156. http://www.iaees.org/publications/journals/piaees/articles/2022-12(3)/factors-affecting-adoption-of-storage-rainwater-harvesting.pdf

Tolossa, T. T., Abebe, F. B., & Girma, A. A. (2020). Review: Rainwater harvesting technology practices and implication of climate change characteristics in Eastern Ethiopia. *Cogent Food & Agriculture*, *6*(1), 1724354. https://doi.org/10.1080/23311932.2020.1724354

Wang, J., Ying, W., Hua, L., Zhang, H., & Wang, R. (2022). *Global practical potential for metal–organic frameworks assisted atmosphere water harvesting*. https://doi.org/10.21203/rs.3.rs-2003923/v1

Xu, W., & Yaghi, O. M. (2020). Metal-Organic Frameworks for Water Harvesting from Air, Anywhere, Anytime. *ACS Central Science*, *6*(8), 1348–1354. https://doi.org/10.1021/acscentsci.0c00678

Zhang, L., Yu, Y., Malik, I., Wistuba, M., Sun, L., Yang, M., Wang, Q., & Yu, R. (2022). Water Resources Evaluation in Arid Areas Based on Agricultural Water Footprint—A Case Study on the Edge of the Taklimakan Desert. *Atmosphere*, *14*(1), 67. https://doi.org/10.3390/atmos14010067