





# The Role of Artificial Intelligence in Water Resource Management in North Africa: Challenges and Opportunities

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## Abstract

Given the water Scarcity Challenges facing North Africa due to climate change and population growth, which necessitate sound governance to prevent the excessive depletion of potable water, artificial intelligence (AI) has recently emerged as a crucial tool for improving the efficiency of water resource management and achieving the Sustainable Development Goals (SDGs), particularly SDG 6 on water. The rapid expansion of AI applications offers a means to address numerous emerging challenges through practical technologies in various fields, such as water treatment and water level and ratio forecasting. This reflects the positive role of AI in water management in North Africa and in achieving water security through sound governance that ensures sustainability and fosters economic development.

**Keywords:** Climate change, Water security, Sustainable development

## 1. Introduction:

Wherever there is water, there is life. How could it be otherwise? The economic importance of water is increasing day by day. The use of water in agriculture, industry, irrigation, electricity generation, and other uses has made it a focus of attention for all countries. This has made access to fresh water one of the biggest and most important challenges in our modern era, especially in order to avoid international conflicts. This has prompted many countries to establish agreements that regulate the exploitation of international waters and rivers, as well as shared groundwater. Among these are the countries of the Middle East and North Africa (MENA) region, which face increasing water challenges as a result of natural water scarcity, climate change, population growth, and poor governance. In light of these challenges, artificial intelligence has emerged as a modern tool relied upon to improve water resource management and increase the efficiency of its use. This is especially true given that all studies indicate that by 2050, two-thirds of the world will suffer from

a 40 % water shortage, exacerbating the global water crisis. Consequently, water scarcity in the Arab region poses a significant challenge to sustainable development,

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and concerns about water scarcity affect water security. The focus on AI-powered technologies has become the desired direction for all countries in the region to ensure the equitable and sustainable use of water resources for the benefit of present and future generations.

This leads us to pose the following questions:

**How can artificial intelligence contribute to the rational use of shared water resources in North Africa?**

**And how can artificial intelligence conserve and protect these waters from all forms of depletion, thus ensuring their sustainability?**

**The importance of the study:** Water is the lifeblood and foundation of development in all fields. Given the world's climate change, which has made the water problem a top concern for all countries, especially regarding shared water resources, which require rational management to maintain the sustainability of the resource and avoid conflicts between countries, as well as its sustainability, especially with the digital transformation and technology, artificial intelligence has become one of the challenges that countries use in how to manage and run water resources, through its advanced technologies that facilitate rational use and resource management.

**Study objectives:** Through the current topic, we seek to know the areas of use of artificial intelligence and how it is used as a tool to manage water between countries in a way that ensures its sustainability for future generations, and to highlight the importance of regional cooperation and data exchange to ensure the achievement of water security, while mentioning some successful scientific experiences in the field of artificial intelligence and water in order to activate this mechanism and work with it to achieve development.

**Methodology:** In this study, we adopted both the analytical and descriptive methods by explaining and describing the reality of water resources in the region, as well as identifying the main challenges facing the countries of the region.

**Research division:** The topic of the intervention falls under the seventh axis of the conference, and I divided it into two axes. The first axis addressed the importance of artificial intelligence in water resource management, and the second axis addressed the challenges facing artificial intelligence in water exploitation.

## **2. The Importance of Artificial Intelligence in Water Resources Management**

Artificial intelligence is a set of devices, systems, technologies, programs, and applications that collectively form a set of cognitive processes performed automatically and in the form of algorithms. These processes aim to analyze data in order to solve problems and improve decision-making with extreme accuracy. [1]

Artificial intelligence (AI) has permeated all fields and become a strategic tool used in water resource management, especially with the increasing demand for water. With climate change, AI is also playing a pivotal role due to its superior ability to analyze hydrological, climatic, and agricultural data in a short timeframe, unlike traditional methods.

AI helps predict climatic phenomena such as droughts and floods through predictive models based on machine learning and neural networks. [2] This enables relevant authorities to take proactive measures to mitigate the effects of these phenomena. This, in turn, improves water planning in the medium and long term and ensures a more equitable and efficient distribution of available water resources.

AI is also used in managing water distribution networks through intelligent systems capable of monitoring pressure and flow within the networks and detecting leaks and malfunctions early. [3]

These applications are particularly important in North Africa, where numerous reports indicate high rates of water loss due to aging infrastructure and inadequate maintenance systems. Reducing this water loss contributes to enhancing water security and optimizing public spending allocated to the water sector.

In the agricultural sector, the largest consumer of water resources, smart irrigation technologies represent one of the most prominent applications of artificial intelligence. These systems rely on integrating data on soil moisture, temperature, crop type, and weather forecasts to determine the optimal irrigation quantities at the right time. This leads to reduced water waste, improved crop productivity, and a balance between food security requirements and the preservation of natural resources.

Furthermore, artificial intelligence (AI) contributes to improving the management of dams and reservoirs through simulation models that aid in making accurate decisions regarding water storage and release. This ensures optimal use of water resources and mitigates the risks associated with flooding or water scarcity. Water resources have become one of the most sensitive strategic issues in recent decades, particularly in water-scarce regions such as North Africa and the Middle East. Pressure on these resources has increased due to several factors, most notably rapid population growth, urbanization, climate change, and rising water demand in the agricultural, industrial, and domestic sectors. In light of these challenges, AI has emerged as an advanced technological tool capable of revolutionizing water resource management methods by improving use efficiency, enhancing predictive capabilities, and supporting sound decision-making.

Artificial intelligence refers to a set of technologies and systems capable of mimicking human cognitive abilities, such as learning, analysis, inference, and decision-making, relying on advanced algorithms and big data. The application of these technologies in the water sector has opened up vast possibilities for more sustainable and effective water resource management

## **2.1 Efficiency in Water Management and Governance Between Countries**

By analyzing pressure, flow, and water quality sensor data, intelligent systems can pinpoint fault locations with high accuracy and at an early stage. This reduces the loss of large quantities of water and lowers maintenance and repair costs.<sup>3</sup> Another aspect of improved efficiency is the shift from traditional maintenance methods, which rely on intervention after a failure occurs, to predictive maintenance based on artificial intelligence. Intelligent models allow for the prediction of potential failures in water infrastructure before they happen, based on the analysis of network behavior and past failure patterns. This contributes to extending the lifespan of water facilities and improving their economic viability. [4]

Furthermore, artificial intelligence contributes to improving water use efficiency at the end-use level through intelligent demand management systems, particularly in major cities. These systems enable real-time monitoring of consumption, provide recommendations for rationalizing use, and support fair water pricing policies, in line with the goals of sustainable water resource management. [5]

## **2.2. Sound Planning in Water Decision-Making**

Planning and decision-making are cornerstones of using artificial intelligence (AI) in sustainable water governance. AI programs assist decision-makers in analyzing and understanding technical data, enabling them to manage water systems effectively. The intelligent models used help develop more precise and effective water policies.

AI technologies are used to predict droughts and floods, making them essential tools that support strategic planning and allow decision-makers to anticipate the effects of policy choices before adopting them.<sup>7</sup> Furthermore, AI plays a crucial role in integrating multi-source data into a unified analytical system. This includes data from satellites, hydrological monitoring stations, and national statistical databases, improving forecasting accuracy and enhancing early awareness of water-related issues. This, in turn, positively impacts the ability to manage and control risks with minimal economic and social losses.

## **2.3. Achieving Equitable and Sustainable Groundwater Use**

Undoubtedly, agriculture consumes a significant amount of freshwater, the demand for which increases annually. Artificial intelligence has played a crucial role in developing smart farming systems by analyzing soil, weather, and all crop-related factors to optimize irrigation water needs.

This makes AI-assisted irrigation a way to reduce excessive water consumption without negatively impacting overall water use, thus contributing to the sustainability of water resources for future generations and achieving water security .

Furthermore, AI facilitates the prediction of droughts, rainfall, and all the effects of climate change, helping farmers adapt to these impacts.

Since groundwater constitutes a large percentage of the world's freshwater, it is a crucial element in meeting water needs, especially in arid and semi-arid regions. This makes its unregulated exploitation depletion essential, necessitating the use of artificial intelligence (AI) to find smart solutions through the analysis of geohydrological data and the determination of water levels and aquifer quality.

AI techniques are used to analyze complex geohydrological data, such as water levels, aquifer quality, and pumping rates, to predict the future state of groundwater reservoirs. This facilitates and establishes sound policies based on the equitable and sustainable use of this resource.

### **3. Challenges Facing Artificial Intelligence in Water Utilization**

Despite the significant benefits that artificial intelligence provides in water management, its application remains subject to several challenges related to different aspects, which may affect the effectiveness of AI-based water management systems. Therefore, it is necessary to analyze these challenges to ensure a balanced and responsible use of artificial intelligence in the water sector.

#### **3.1. The Impact of Artificial Intelligence on Water Resource Sustainability**

While artificial intelligence has significantly contributed to finding innovative solutions for water resource management, its applications face major environmental challenges, most notably the water footprint left by AI infrastructure. Given that AI relies on massive databases, requiring high levels of electricity and large quantities of water for cooling, it depletes precious water resources, particularly in arid regions already facing water scarcity challenges, such as the Middle East and North Africa.

Data centers consume water in various ways, both directly, which includes using water in cooling systems to dissipate the heat generated by servers during computing, where water consumption can reach thousands of liters per megawatt-hour (L/MWh) of electricity produced, and indirectly, where indirect consumption includes the water used to generate the electricity needed to operate these centers via power plants, which in turn use water in the cooling and condensation process.

In this context, recent studies have shown that the water consumed often goes to evaporation or is discharged away and is not returned for use in drinking or irrigation, which constitutes another form of pressure on local water resources.

Therefore, a major challenge lies in the unsustainable expansion of artificial intelligence use, which could lead to increased water demand for purposes that do not contribute to improving and rationalizing water resource consumption. This presents an environmental contradiction that raises questions about the sustainability of this technology in regions already suffering from water scarcity. This necessitates the development of robust governance frameworks and environmental policies that keep

pace with this technological expansion and achieve a balance between operational benefits and the environmental and water-related costs.

### **3.2. The Role of Artificial Intelligence in Water Quality Monitoring and Decision Support**

In addition to improving water use efficiency, artificial intelligence plays a crucial role in monitoring water resource quality, which is of paramount importance for protecting public health and the environment. Thanks to smart sensors and Internet of Things (IoT) technologies, it is now possible to collect real-time data on the physical and chemical properties of water, such as pH, pollutant levels, and turbidity.

AI algorithms enable the continuous analysis of this data and the early detection of any deterioration in water quality or sudden pollution, allowing for rapid intervention and mitigation of potential negative impacts. These technologies also contribute to improving the efficiency of water treatment plants by automatically adjusting operational processes according to the quality of the incoming water.

In the area of decision support, AI provides advanced analytical tools that help policymakers evaluate various water resource management scenarios. Predictive models allow for the simulation of the effects of proposed water policies, whether related to water pricing, distribution among different sectors, or the management of shared water resources between countries. In this context, the importance of integrating artificial intelligence (AI) into shared water resource management is highlighted, as exemplified by the Algerian-Tunisian experience. AI technologies can contribute to the development of joint monitoring systems for transboundary water basins. These technologies also help improve data and information

### **3.3. Algeria's Experience in Water Governance in North Africa: Dr. Abdelrahman Noui's Experience in Biskra as a Practical Model**

The presence of a water reservoir in Algerian territory is of such importance that it makes it a significant resource worthy of study and focus. Located in the south, in arid regions, it offers the potential to be utilized to make the Algerian Sahara green and serve both the economy and tourism.

This reservoir is the Saharan Aquifer, which extends between Algeria, Tunisia, and Libya, covering an area of 1 million square kilometers. It is a strategic resource, especially in regions experiencing low rainfall and facing ongoing climate change.

Algeria is well aware of the importance and necessity of preserving this aquifer, which led it to conclude a tripartite cooperation agreement under the supervision of the Saharan Groundwater Observatory. The goal is to ensure the efficient use of water resources among the three countries, and to guarantee equitable use and distribution, in order to avoid future conflicts that could threaten good neighborly relations.

This also aims to protect the water reserves from indiscriminate depletion and ensure their availability for future generations, thus achieving sustainable development.

The experience of Algerian researcher Abdelrahman Noui in the Biskra region represents an important practical model for employing artificial intelligence in water resource management in an arid environment subject to environmental pressures. In a recent applied study, Noui used artificial intelligence techniques, along with geographic information systems and remote sensing, to analyze the state of groundwater in Biskra a region experiencing a sharp decline in groundwater levels and an increase in salinity due to over-pumping.

The study also addressed the geophysical analysis of aquifers to identify reservoir areas most vulnerable to depletion and salinization, in addition to using AI-powered slope models to predict water level evolution and provide useful time data for decision-makers; this demonstrates the importance of relying on artificial intelligence not only for real-time monitoring and observation but also for proactively predicting water crises. [6]

This type of application is a step towards digital water governance because it provides accurate and reliable data to improve decisions related to resource allocation, reduce water waste, and develop strategies for replenishing aquifers, in line with the Sustainable Development Goals in arid regions (figure 1).

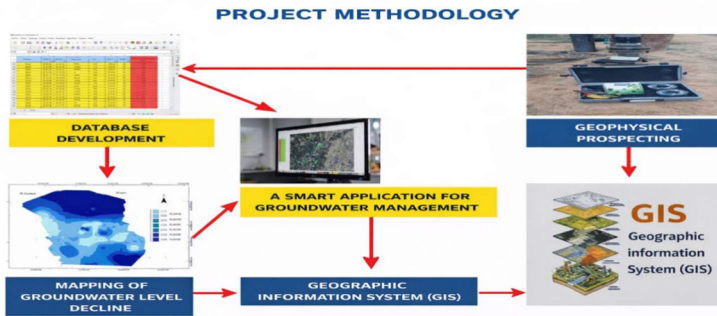


Figure 1. Methodology of Dr. Abdelrahman Noui’s project for groundwater management using AI techniques

## 4. Conclusion

The advantages of artificial intelligence (AI) in water governance are numerous across various countries, aligning with the technological revolution and digital transformation sweeping the world, particularly in the field of water use. This ensures the achievement of sustainable development goals and fosters sound governance through balanced policies that guarantee water security and prevent water depletion. This has made AI a powerful tool for addressing environmental and economic challenges. While AI can improve water resource management in the MENA region, its complete success remains contingent upon its integration into sustainable water policies that consider environmental impacts. The experience of researcher Dr. Abdul Rahman Al-Nawi demonstrates that the transition towards AI necessitates achieving a balance between technological innovation and sustainable governance.

### Main Findings of the Study

Artificial intelligence significantly enhances the efficiency of water resource management through advanced data analysis and predictive models.

Artificial intelligence technologies contribute to the early forecasting of droughts and water crises, which supports strategic planning and sustainable water governance.

Smart irrigation systems and monitoring help achieve a more rational and efficient use of water resources, especially in agriculture.

The integration of artificial intelligence with geographic information systems and remote sensing technologies improves groundwater monitoring and supports evidence-based decision-making.

Regional cooperation and data exchange between North African countries remain an essential condition for the sustainable management of shared water resources.

### Prospects for Good Governance in AI-Powered Water Management

Ensuring the effective and sustainable use of artificial intelligence (AI) in water management requires a comprehensive legal and regulatory framework based on several key principles:

#### A. Integrating AI into National Water Policies

Digital technology should be integrated into the national strategic framework for water management, with clear responsibilities, environmental standards, and performance indicators that link AI use to sustainability goals and reducing the water footprint. This necessitates establishing standards for measuring environmental impact before and after the deployment of digital solutions.

## **B. Strengthening Regional Cooperation**

Cooperation among MENA countries is essential for regulating the use of shared data and coordinating strategies, particularly in transboundary water basins. This cooperation can benefit from experiences such as the AI4WATER projects in the Mediterranean basin, which focus on the intelligent use of water data through AI technologies.

## **C. Ensuring Water Equity and Environmental Sustainability**

Governance policies should consider equitable distribution across rural and urban populations and ensure that the use of artificial intelligence does not exacerbate inequalities in water access. These policies should also include the use of non-water cooling methods for data centers or the recycling of water used for cooling to reduce the water footprint, which requires explicit guidance at the national and regional levels.

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