

## **The Role of Artificial Intelligence in Enhancing Water Resource Management Efficiency**

**ZERROUKI fatma zohra<sup>1\*</sup>, KHIREDDINE Amine<sup>2</sup>**

<sup>1</sup> University Center of Tipaza (Algeria), zerrouki.fatmazohra@cu-tipaza.dz

<sup>2</sup> University Center of Tipaza (Algeria), Khireddine.amine@cu-tipaza.dz

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### **Abstract:**

The aim of this study was to explore and analyse the role of artificial intelligence (AI) technologies in enhancing the efficiency and sustainability of water resources management, as well as the various economic implications of using these technologies in the future. We adopted a descriptive approach, which is well-suited to addressing the various concepts related to AI technologies. We also used statistical data to analyse and interpret the extent to which applying these technologies enhances the efficiency and sustainability of water resources management.

The study concluded that using these modern technologies contributes to the integrated and sustainable management of water resources.

**Keywords:** Artificial Intelligence, Water Resources, Water Innovation

**JEL Classification:**L60 ; Q3

## **Introduction**

Artificial Intelligence (AI) technology is one of the most prominent technological developments of recent years, affecting all aspects of daily life and changing the face of many industries. According to the *McKinsey Global Report*, it will contribute 1.2 to 2 trillion US dollars to the economy by 2025. AI will promote sustainability by making the rational use of resources and reducing energy costs, thereby reducing the environmental impact of industrial processes.

Technology and innovation are among the most important drivers of economic growth, positively impacting the productivity of various sectors. This applies to the water sector, which urgently needs to realise its full growth potential, especially given the challenge of meeting the growing demand for water in the context of a growing population. In light of the current global challenges regarding water shortage and pollution, Artificial intelligence technologies offer new ways to improve water resource management by analysing big data and providing valuable insights to help make more informed decisions. These include technologies for detecting and repairing leaks, innovative wastewater treatment and activating its use for non-domestic purposes. These technologies will contribute to achieving water sustainability by improving transmission and distribution, and by innovatively treating wastewater for non-domestic use.

Thus, we posed the following problematic : **How can AI technologies enhance the efficiency of water resource management?**

In order to answer this problematic, we asked the following sub-questions :

- What is artificial intelligence, and what are its main applications and types?
- How does AI contribute to the development of various economic sectors?
- What is the role of AI techniques in water resources management?

**Study hypotheses :** As a preliminary response to the sub-questions, we propose the following hypotheses:

- Artificial intelligence represents the ability of machines to imitate human behaviour and has multiple applications, including in the fields of health, education and industry.
- AI contributes to the development of economic sectors by improving efficiency and reducing costs.

- The use of AI techniques helps to manage water resources more effectively by predicting consumption and minimising waste.

*To analyse the topic and identify the elements of the issue, this study covered the following areas :*

- Basic concepts of artificial intelligence.
- The effects of using AI applications on certain economic sectors.
- The role of artificial intelligence techniques in managing water resources.

### **The importance of the study:**

This study enables us to identify the role that AI technology can play in rationalising water consumption and enhancing the efficiency of water resource management. This allows us to ensure the long-term sustainability of water resources, which is especially important given the growing issue of achieving water security at a global level.

### **1- Basic concepts about artificial intelligence:**

The term 'artificial intelligence' emerged in the 1950s. In 1950, some researchers worked on a project with this name, and in 1956, **John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon** organised a conference at Dartmouth University. The researchers at this conference suggested that a machine could be designed to simulate any task requiring human intelligence. **John McCarthy**, nicknamed the father of artificial intelligence, formed the basic nucleus of artificial intelligence. He considered it a technical experiment to develop a machine capable of independent human thinking (Gneih, 2022, p. 218)

#### **1.1 Definition of artificial intelligence (AI):**

There are many definitions of AI, all of which relate to the development of machine technology and intelligent behaviours. AI is defined as 'the ability of a machine to perform cognitive functions associated with the human mind, such as perception, reasoning, learning, interacting with the environment, solving problems and exercising creativity'. Thus, AI is a combination of advanced computational techniques at various stages of development (Geetha, 2021, p. 110).

AI is also defined as a branch of computer science that enables the creation of computer programmes that mimic human intelligence, allowing computers to perform tasks that require thinking, understanding, hearing, speaking, and moving in a logical and organised manner (Bakari, 2022, p. 290).

Oracle defines it as 'systems or devices that mimic human intelligence, performing various tasks and improving based on the information they collect. They are characterised by their ability to think on their feet and analyse data' (El-Sharkawy, 2023, p. 289).

From the previous definitions, we can conclude that artificial intelligence is 'one of the branches of computer science concerned with designing machines and computer programs that can simulate intelligence. It is currently present everywhere around us, from self-driving cars and drones to translation software.' AI is based on advanced programs that simulate the human mind, and huge amounts of data are used, analysed and tracked to reach conclusions and make decisions or simulate the human mind.

There are several types of AI, which vary according to the field of use, the level of AI used and the amount and type of data used.

### **1.2 Types of Artificial Intelligence:**

There are several types of artificial intelligence, which vary according to the area of use, the application of artificial intelligence, the level of artificial intelligence used and the amount and level of data used.

#### **A. Types of artificial intelligence by application use areas:**

The artificial intelligence market comprises several major types, depending on the field of use:

- **Machine learning:** The science of enabling machines to interpret, execute and verify data using developed algorithms coded in a machine-understandable language, with the aim of finding solutions to issues faced by humans in daily activities.
- **Neural network:** This is a type of artificial intelligence application that imitates the human brain by integrating neuroscience and artificial intelligence in a flexible way. It can solve complex tasks through rapid learning and the ability to adapt to dynamic environments. The main idea is to simulate the nervous system's ability to recognise patterns and distinguish objects. Neural networks are designed similarly to biological nervous systems, where each neuron consists of a cell body that processes data and information, bringing it to and from the brain for learning and producing knowledge. This is achieved by creating new structures for the processing system through the first two layers. (Soori, 2021, p. 2)
- **Robotics:** These applications combine the disciplines of science, mechanical engineering, electrical engineering, computer science and other sciences. According to the American Robotics Institute,

robots are 'processors designed to move equipment, parts, objects and materials, as well as perform tasks and functions through programmed (Adel, 2005, p. 65) Robots are used instead of humans because they are highly intelligent and can execute programmed commands accurately and efficiently. They are used in the automotive industry, for repairing complex extensions and in other precise and complex fields.

- **Expert systems:** These systems simulate decision-making processes relying on human and artificial intelligence techniques to solve complex issues based on logical thinking. They are used to solve specific problems in certain fields, with the thought processes for solving a problem carried out by a professionally qualified human expert. This constitutes an artificial advisory system that analyses the data associated with the issue at hand and proposes correct solutions for decision-makers. These systems are structured on cognitive bases and built on computers using developed software that relies on a knowledge base to create expert systems in specific fields. The inference methodology consists of the following: (J.F Lucas, 1991, p. 5)
- **Fuzzy Logic:** It is an artificial intelligence application that analyses and modifies uncertain information. It deals with uncertainties by measuring the validity of different hypotheses. Fuzzy logic is also used to analyse uncertainties based on the logical thinking assumptions of the human mind. It is a system of principles used in approximate and exact deduction methods. It is used in decision-making and control systems, as well as in technical industries, robot controls, and modern cars (Raed Abdul Qader Hamed, 2011, p. 202).
- **Neuro-Linguistic Programming (NLP):** NLP specialises in developing advanced methods to facilitate communication and interaction between machines and natural human languages. It plays a pivotal role in many applications we use daily, such as web searches, machine translation, text recognition, and content analysis.

**B. Types of artificial intelligence according to IQ scores:** (Heba Abdel Moneim, 2021, p. 9):

- **Narrow weak artificial intelligence:** It is represented by simple calculations performed by calculators and the limited intelligence that computers rely on. This intelligence is mainly based on programming operations and enables computers to perform specific tasks with a level of efficiency that exceeds human capabilities.

- **Narrow strong AI:** At this level, systems can acquire basic learning skills by collecting information to produce new, albeit limited, information, thus lacking human expertise.
- **Narrow general AI:** These systems have a greater capacity to learn, are not necessarily based on pre-programming and can use previous experiences to interact with new data and produce impressive results.
- **Robust artificial general intelligence:** These systems can learn anything without programming and fully emulate the human mind, including all stages of cognition and sensation.
- **Super AI:** Computers that can think just like humans, and even outperform them due to their superior intellectual capabilities. Some predict this will happen in 2099.

### **C. Types of artificial intelligence according to the level of data utilisation:**

Artificial intelligence systems generally use a large amount of data, so they benefit greatly from the development of data science. These systems are divided into two categories: (Khan, 2021, pp. 368-375)

- **Machine learning:** These systems use algorithms to simulate and draw conclusions based on information, providing advice on future possibilities. Examples include systems used in the financial and banking sectors. However, these systems remain dependent on the information provided to them and cannot adapt to new patterns of behaviour.
- **Deep learning:** This stage involves moving to a higher, more complex level of machine learning. It requires complex architecture that mimics the human mind in terms of neural network structure. These systems can think and make decisions, even with missing data or greater uncertainty. They have tremendous capabilities but require enormous amounts of data and computational power.

**1.3 Impacts of AI on certain economic sectors:** The economic impact of AI on different sectors varies according to two main factors:

- The ability to apply autonomy, which will be evident in labour-intensive sectors such as agriculture.
- The amount of added value that AI technologies bring to each sector.

#### **1.3.1 Uses of AI in the agricultural sector:**

AI technologies can be one of the most important pillars in developing the agricultural sector. They have contributed to the expansion of precision

agriculture and helped farmers to obtain high-quality crops by promoting the sustainable use of resources. The most important uses of AI applications in agriculture are as follows:

**A. Use of self-driving tractors:** This technology combines remote sensing (GPS) and automation to enable precise driving and prevent excessive soil compaction.

**B. Pest and insect control:**

According to the Food and Agriculture Organization of the United Nations (FAO), 20–40% of the world's cereal crops are currently lost or damaged due to pests and insects. These are among the most common threats to crops before they are harvested and stored for human consumption. AI companies such as Farm Wise send out alerts and use algorithms to analyse new satellite images and compare them with previous image data. This allows farmers to mitigate damage and remove pests in a timely manner (Abdel-Al, 2014, p. 57).

**C. Agricultural drones:**

These drones can monitor crop growth and production, as well as identifying weeds and damaged plants. They can also be used to analyse terrain using cameras and other sensors for precision farming. The agricultural drones market is expected to exceed \$1 billion by 2024 (Korab, 2022, pp. 117-135).

**D. Agricultural robots:**

AI companies are developing robots that can perform a variety of agricultural tasks. These robots are trained to control weeds and harvest crops much faster than humans can. Companies are using computers and deep learning algorithms to analyse data collected by drones. *Blue River Technology and Harvest CROO Robotics* are two companies building this type of robot, which can harvest up to 30,000 square metres of land in one day. This saves time and effort, and reduces the number of workers needed.

**E. Expansion of precision agriculture:**

AI applications help to expand precision agriculture by providing farmers with real-time guidance on optimal planting, water management and harvesting in time. This type of agriculture uses mathematical software and big data captured from soil sensors to save up to 90% of water resources compared to traditional agriculture. It also reduces the use of fertilisers, which increases agricultural yields and helps to achieve food security around the world.

**1.3.2 The use of AI applications in the energy sector:**

The energy and renewable energy sector is a growing economic force, offering an effective strategy for improving environmental sustainability. AI

is being used increasingly in this field to manage renewable energy, deal with energy fluctuations, and optimise energy storage. AI also monitors and collects information on energy consumption in buildings and factories, helping to control energy use during peak hours (Shandi, 2019, pp. 112-135).

## **2. The Future Economic Opportunities and Challenges of AI:**

The use of AI is characterised by a number of economic opportunities and future challenges.

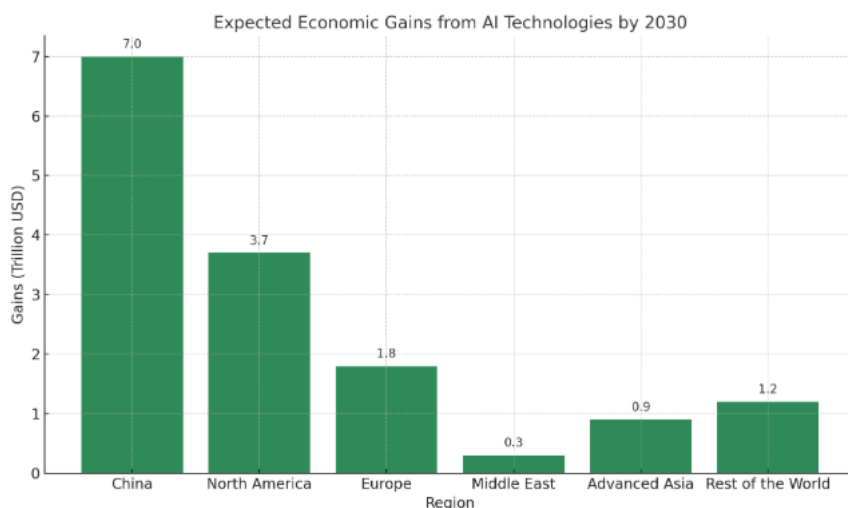
### **2.1 Future economic opportunities for AI:**

AI is an important area of innovation for achieving digital sovereignty and economic prosperity. This has prompted many industrial organisations to change their strategies in order to seize the opportunities offered by these technologies. AI applications are expected to contribute up to 14% to global GDP growth in 2030 — equivalent to around \$16 trillion — and have already entered the manufacturing, transport and storage, and robotics and self-driving vehicles sectors. However, progress in the use of AI technologies requires regulatory controls to encourage investment and funding in this field.

In 2021, the value of the artificial intelligence market was approximately \$328 billion. It is projected to reach \$1.394 trillion by 2029, representing a growth rate of 20%. The market size in North America reached \$144 billion, and revenues from artificial intelligence chips worldwide are anticipated to surpass \$80 billion within the next five years. Furthermore, 83% of companies consider artificial intelligence a primary focus of their strategies, and it is estimated that 97 million individuals will be employed in the artificial intelligence sector by 2025 (Sadek, 2023, pp. 8-9)

Conversely, the global economic crisis has affected AI applications, with global funding dropping by 34 per cent to \$45.8 billion in 2022, and AI acquisitions or mergers falling by 17 per cent to just 259 deals in the same year.

**Figure 1. Projected economic gains from AI technologies globally by 2030**



**Source:** (Heba Abdel Moneim, Economic implications of the fourth industrial revolution - Artificial Intelligence, Economic Studies, United Arab Emirates, Issue 78, 2021, p. 19)

Figure 1 shows that China is expected to make the largest economic gains by 2030, at around 26.1 trillion US dollars. This would account for 70% of the expected global economic gains, followed by North America and Europe, and then developing Asia. The rest of the regions are expected to record modest gains due to a lack of capabilities to develop this technology. (Heba Abdel Moneim, Economic implications of the fourth industrial revolution - Artificial Intelligence, Economic Studies, United Arab Emirates, Issue 78, 2021, p. 18)

In the labour market, the widespread use of AI technologies is expected to create 40–50% more job opportunities by 2030, particularly in roles requiring high digital skills. As for wages, around 13% of total payroll costs are projected to be allocated to employees with advanced technical qualifications, while wages for unskilled workers are anticipated to decline by 20–33% between 2020 and 2030. This will lead to an increase in large-scale competitive companies, and consequently, the market for technology-focused startups will expand. In the first half of 2023, \$12.5 billion was invested in AI start-ups, compared to \$4.5 billion in 2022.

## **2.2 The future economic challenges of artificial intelligence:**

The growing role of AI applications and their increasing use in the economic sector is expected to lead to many challenges, which can be summarised as follows: (Korinek, 2024)

### **A. High costs and lack of high return on investment:**

Initially, the cost of implementing AI technologies in industry can be very high, for example in terms of spending on sensors, cloud storage, administrative and technical labour, and so on, which means that companies may find it difficult to justify investing in these technologies.

**B. Data collection and model training:** Artificial intelligence techniques require training models on data takes time and effort, especially if the data is not readily available or is unstructured.

If the data is available in an unstructured form, this will also require additional time and effort. Therefore, the quality of the data must be considered to achieve the best results and decisions.

In such cases, the quality of the data must be considered to achieve the best possible results and decisions.

**C. Privacy and security:** AI technologies require the collection and analysis of large amounts of data, which may have a significant impact on users' personal data or even this will lead to an increasing struggle for control of and access to that data between companies, service providers, individuals and even governments. This is especially pertinent in light of the growing risk of cybercrime and cyber-attacks against organisations. This could lead to a growing struggle for control and acquisition of this data among service providers, individuals and even governments. This could lead to economic losses in the future.

### **3. The Role of Artificial Intelligence in the Water Sector:**

Like any other economic sector, artificial intelligence technologies play an important role in the water sector, minimising the challenges it faces by proposing smart solutions that promote rational consumption and preserve this important natural resource.

#### **3.1 An overview of the state of the world's water resources:**

More than 40% of the world's population is affected by water scarcity, and water-related disasters account for 70% of all deaths associated with natural disasters. Rationalising water use by building resilience to climate change and promoting integrated water resources management (IWRM) will enhance the sustainability of this vital resource.

Today, most countries are facing unprecedented pressure on their water resources. Due to the rapid population increase, it is estimated that, if current practices continue, there will be a 40 per cent shortfall between the projected demand for water and the available supply by 2030. Chronic water scarcity, hydrological uncertainty and extreme weather events, such as floods and droughts, which have become more frequent in recent years, are among the greatest threats to global prosperity and stability.

Feeding a global population of 10 billion by 2050 will require a 50 per cent increase in agricultural production. This sector currently consumes 70 per cent of the world's freshwater resources and this increase will further strain the global water supply. Currently, it is estimated that more than 40 per cent of

the world's population lives in water-scarce regions and nearly 25 per cent of the global GDP is affected by this issue. By 2040, one in four children will live in areas experiencing severe water shortages. Water security is a major challenge for many countries today.

Climate change will exacerbate this situation by altering water system cycles and making water supplies more unpredictable. It will also lead to an increased frequency and severity of floods and droughts, which will have a particularly detrimental effect on poor rural communities that rely heavily on rainfall for agriculture.

The world's freshwater resources are fragmented, with 276 transboundary basins shared by 148 countries accounting for 60% of global freshwater flow. More than 300 transboundary aquifer systems also exist, with 2.5 billion people relying on groundwater. Five billion people worldwide depend on groundwater. This calls for regional and international cooperation to exploit these water resources and develop the most effective management strategies for all countries bordering international waterways.

In order to address these complex and interconnected water challenges, countries must improve the way they manage their water resources and associated services. This can be achieved by investing in stronger institutional frameworks, improved information management and infrastructure development. Institutional tools such as legal and regulatory frameworks, water pricing and incentives are necessary to improve the allocation, management and conservation of water resources. Information systems must also be used to monitor and track resources, make decisions in uncertain situations, perform network analyses, make forecasts and issue hydrometeorological warnings. Investment in innovative technologies is needed to enhance productivity, conserve resources, recycle stormwater and wastewater, develop unconventional water sources and seek opportunities to enhance water storage, including recharging aquifers and restoring this important resource. This will enhance global water security. (WORLD BANK GROUP, 2024).

### **3.2. Modern technology in the water sector:**

Modern technology plays a key role in improving water management by helping to rationalise consumption, detect leaks and enhance water quality. The use of sensors and smart systems enables accurate monitoring of water

distribution and helps save water at a lower cost. These technologies also help to address water scarcity and climate change more effectively.

### **3.2.1. Advanced reverse osmosis systems:**

Advanced reverse osmosis systems utilise technologies that optimise the performance of upgraded desalination plants. These plants use thin, semi-permeable membranes with narrow pores to filter out impurities such as dissolved salts and bacteria, while allowing pure water to pass through. This technology is considered a leader in desalination today because it lowers the cost of desalinating seawater to meet residential and industrial demand, and it will utilise water for the agricultural sector in the future. These technologies are classified under desalination system technologies, including membrane materials, energy recovery devices and broader equipment improvements, such as pumps and valves. They also include to optimising RO system settings to improve efficiency and reduce pollution. Global demand is expected to grow, with the value of the advanced reverse osmosis market increasing from \$2.5 billion in 2019 to an estimated \$9.9 billion by 2032. It is expected to reach \$9.2 billion by 2032. This is due to the adoption of energy-efficient reverse osmosis plants compared with those that rely on thermal methods. (WORLD BANK GROUP, 2024, p. 36)

### **3.2.2. Smart Leakage Management:**

Smart leakage management relies on advanced technologies to detect, locate and mitigate leaks in the transport and distribution stages of the water value chain. These technologies are represented by remote sensors and artificial intelligence. Smart leakage management includes several stages:

- **Direct leak detection:** This involves using technologies such as manual inspection of the on-site distribution system, robotic leak detection, gas trace sensing and laser technology to identify leaks.
- **Remote leak detection:** This involves using advanced technologies and data analysis processes to identify leaks without physically accessing the water distribution system. This method relies on sensor networks, data collection devices and communication technologies, such as water flow sensors, pressure sensors, hydraulic modelling and SCADA systems.
- **Leak mitigation technologies:** These are the technologies, devices and systems used to identify leaks early on, mitigate their impact and prevent further damage. Examples include remote welding and painting of joints and the automatic sealing of leaks with viscous treatment materials (WORLD BANK GROUP, 2024, p. 38)

### **3.2.3 Wastewater treatment and reuse:**

This includes two technology clusters that focus on wastewater treatment and recycling. Due to water scarcity, wastewater reuse is essential but requires appropriate technologies. The process includes technologies such as:

**A. Innovative treatment:** This involves advanced processes and technologies for treating wastewater, such as removing suspended solids, biological treatment, disinfection, adsorption and desorption.

**B. Adaptive technologies for wastewater reuse:** These include water recycling systems, filtration systems and grey water recycling systems.

The global wastewater treatment and reuse technologies market is expected to grow from \$178.7 billion in 2023 to \$236.2 billion by 2028. The Middle East and Africa are expected to experience the fastest growth, with CAGRs of 9.3% and 8.3% respectively, due to increased investment in sewerage infrastructure. Saudi Arabia, for instance, aims to treat 100 per cent of collected wastewater using smart technologies, improving the reuse rate from 17 per cent to 70 per cent and increasing the proportion of the population with access to sanitation services from 60 per cent to 75 per cent by 2030. (WORLD BANK GROUP, 2024, p. 40).

### **3.2.4. Innovative irrigation:**

Innovative irrigation technologies include a variety of systems that aim to optimise water use and increase the efficiency of irrigation, while also ensuring the effective management of water resources. These systems minimise water loss during irrigation and allow the process to be customised according to the needs of the plants and the characteristics of the soil. (Pourmohammad, 2025, pp. 1-11)

**a. Linear irrigation:** This mechanical system distributes water to crops in a straight line using sprinkler mechanisms.

**B. Central Pivot Irrigation:** A mechanical irrigation system that uses sprinklers to water large fields and crops in a circular pattern, with the option of remote sensor control.

**C. Partial or drip irrigation:** This system delivers water directly to the roots of plants in small, controlled quantities via a network of pipes that release water in the form of drops or a slow, steady flow. Remote sensors measure soil moisture and control the amount of water. The market for this technology is expected to grow more than fourfold in the next ten years, reaching USD 15 billion in 2022 and USD 64 billion in 2032.

**D. Smart irrigation:** They are systems that use sensors, weather data and internet connectivity to monitor and adjust irrigation schedules in real time based on prevailing conditions.

Compared to traditional open irrigation systems, innovative irrigation techniques can lead to a significant reduction in water use, with smart irrigation reducing consumption by up to 90 per cent.

### **3.2.5. Innovative approaches to water consumption in homes:**

Innovative approaches to water consumption in homes focus on the adoption of advanced practices and technologies to rationalise water use. These approaches include two main technologies: (Fuentes, 2020)

- **Automated control and management systems:** These systems optimise water use and efficiency in the home by providing processes and technologies such as faucet accessories with displays showing the amount of water flowing, smart low-flow toilet accessories, smart outdoor water control systems, smart toilets.
- **Leak detection and monitoring systems, as well as water-efficient appliances.**

### **3.2.6. Techniques of High Water Efficiency Gardening:**

Water-efficient landscaping practices, such as the use of water-retaining soils, dry gardens, rainwater harvesting systems, micro-irrigation systems and drip irrigation systems, as well as grey water recycling systems, can be adopted in home environments.

Due to growing water-saving practices, the global market for innovative home water consumption technologies is expected to grow from USD 2.5 billion in 2024 to USD 3.8 billion by 2028. (Expo, 2024, December, pp. 22-25)

### **3.3. Reasons for adopting AI technologies in the water sector:**

There are two main reasons for this: (Network., 2024, April 3)

1. The increased demand for innovative technologies and practices to overcome the growing challenges faced by the water sector. These challenges include the global decrease in the level of fresh water and the corresponding increase in demand for this important natural resource. This threatens global water security and affects many other economic sectors, such as agriculture, industry, health, and quality of life.
2. The increasing supply of innovative solutions resulting from rapid technical and technological development has opened the way to

maximising efficiency and increasing productivity in the water sector. Modern digital solutions have become effective in addressing issues such as leakage and consumption rationalisation, while the development of materials science has led to innovative seawater desalination solutions.

### **Conclusion:**

Artificial intelligence technology is determining the competitiveness of countries in all sectors. Perhaps the sector most affected is the economy, given the volume of investments the world is witnessing in artificial intelligence technologies. These technologies play a decisive role in improving the efficiency and sustainability of the water resources sector through advanced applications such as machine learning, data analysis, robotics, and remote sensing devices. AI technologies play a vital role in addressing the growing challenges of water resource management by analysing big data and providing valuable insights. This contributes to improving water use efficiency, predicting water crises and making informed decisions to protect this precious resource. As technology continues to evolve, our reliance on AI in water resource management will increase, ensuring the sustainability of this resource for future generations.

### **This study led to the following conclusions :**

- Artificial intelligence technologies present a significant opportunity for countries facing water scarcity, helping them to overcome various challenges and achieve the sustainable management of this vital resource.
- Although significant progress has been made in applying AI to water resources management, more research and development is urgently needed in this field. We must focus on developing more accurate algorithms and improving our ability to handle complex data. In addition, strong digital infrastructures must be built to support these technologies. By investing in research and development, we can make qualitative leaps in water resources management and achieve sustainable development goals.
- These technologies improve the quality of service in the water sector by rationalising consumption and conserving non-renewable groundwater.
- Providing innovative irrigation solutions increases crop yields and reduces water consumption.

Despite the benefits of AI technology, the potential challenges to its application in water resources management must be considered. The most important of these is the data gap: data is often inaccurate or incomplete, which reduces confidence in the results of intelligent models. In addition, there is the cost of data collection to consider.

Other challenges include cybersecurity, data protection and privacy issues. Technology must be used responsibly and ethically to ensure maximum benefit and avoid potential risks.

**Answering the study's hypotheses:**

\*Artificial intelligence (AI) is the ability of machines to simulate some of the functions of the human mind. It has a wide range of applications in sectors such as health, education, industry and transport. However, its capabilities vary according to the field and the level of technology used.

\*AI contributes to the development of economic sectors by improving operational efficiency, reducing costs and accelerating decision-making. However, its impact varies depending on the nature of the sector and the extent to which technology is adopted. The impact of AI can vary depending on the nature of the sector and the extent to which organisations adopt technology.

\*Artificial intelligence (AI) plays an important role in water resources management. It can predict consumption, optimise water distribution and detect faults early on, helping to rationalise usage and achieve sustainability. However, its effectiveness depends on the availability of data, as well as appropriate technical support.

**Some of our recommendations :**

- Developing countries should benefit from the experience of leading countries in the field of AI and develop national strategies to keep pace with technological developments in this area.
- Digital infrastructures should be developed, investment in advanced sensors should be increased, and the communication network should be expanded to enable the quick and accurate collection of data.
- Strengthening regional and international cooperation to utilise alternative data sources, such as satellite imagery and geospatial data, to bridge the water data gap.
- Strengthening cooperation between the public and private sectors, as well as academia, to develop research into new technologies. This involves concluding agreements with scientific research laboratories

at university level, funding research projects, and utilising national and international expertise.

- Another key objective is to green the process of using artificial intelligence techniques in a way that preserves data.

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