

## The Role of Seawater Desalination Plants in Achieving Water Security in Algeria: An Analytical Study From 2010 To 2025

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### ARTICLE INFO

#### **Keywords:**

Water security, seawater desalination, water scarcity, climate change, water policies, water sustainability, Algeria.

### ABSTRACT

*This study aims to analyze the role of seawater desalination plants in achieving water security in Algeria during the period (2010–2025), in light of increasing pressures on conventional water resources due to climate change, rainfall fluctuations, population growth, and rising water demand across various sectors. The study relied on a descriptive-analytical approach by examining the development of seawater desalination projects, assessing their contribution to meeting water demand, and studying the challenges facing this strategic option. The study's results showed that Algeria witnessed a significant expansion in the number of desalination plants and their production capacities during the study period, particularly in densely populated coastal areas, which contributed to improving the regularity of drinking water supply and reducing dependence on groundwater resources and dams, especially during drought periods. The results also showed that desalinated water has become a key resource within the national water mix and has helped alleviate the severity of water crises in several coastal provinces. On the other hand, the study revealed a set of challenges that limit the effectiveness of desalination as a comprehensive and sustainable solution, foremost among them are high investment and operational costs, heavy reliance on conventional energy, environmental impacts resulting from the discharge of brine, as well as the limited transfer of desalinated water to inland areas. The study concluded that seawater desalination represents an important strategic option to enhance water security in Algeria, but it does not constitute a final solution on its own. Rather, it should be integrated into a comprehensive national vision based on diversifying water sources, rationalizing consumption, improving water governance, and increasing reliance on renewable energy, thereby ensuring the achievement of sustainable water security in the long term.*

#### **JEL classification:**

**Received:** 09.01.2026

**Revised:** 14.02.2026

**Accepted:** 07.04.2026

*Q25, Q54, Q56, H54, O13*

<https://doi.org/10.46361/2449-2604.13.1.2026.44-59>

**ზღვის წყლის გამტკნარების ქარხნების როლი წყლის უსაფრთხოების მიღწევაში ალჟირში: ანალიტიკური კვლევა 2010 წლიდან 2025 წლამდე**  
აბდერაზაკ კადი

ტიპაზას უნივერსიტეტი, მწვანე ეკონომიკისა და განვითარების ლაბორატორია ალჟირში. ტიპაზა, ალჟირი

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ინფორმაცია  
სტატიის შესახებ

აბსტრაქტი

**საკვანძო სიტყვები:**

წყლის  
უსაფრთხოება,  
ზღვის წყლის  
გამტკნარება, წყლის  
დეფიციტი,  
კლიმატის  
ცვლილება, წყლის  
პოლიტიკა, წყლის  
მდგრადობა,  
ალჟირი.

კვლევის მიზანია გააანალიზოს ზღვის წყლის გამტკნარების ქარხნების როლი ალჟირში წყლის უსაფრთხოების მიღწევაში (2010–2025) პერიოდში, კლიმატის ცვლილების, ნალექების რყევების, მოსახლეობის ზრდისა და სხვადასხვა სექტორში წყალზე მოთხოვნის ზრდის გამო წყლის ტრადიციულ რესურსებზე მზარდი ზეწოლის გათვალისწინებით. კვლევა ეფუძნებოდა აღწერილობით-ანალიტიკურ მიდგომას, ზღვის წყლის გამტკნარების პროექტების შესწავლით, წყალზე მოთხოვნის დაკმაყოფილებაში მათი წვლილის შეფასებით და ამ სტრატეგიული ვარიანტის წინაშე არსებული გამოწვევების შესწავლით. კვლევის შედეგებმა აჩვენა, რომ ალჟირში კვლევის პერიოდში მნიშვნელოვნად გაიზარდა გამტკნარების ქარხნების რაოდენობა და მათი წარმოების სიმძლავრეები, განსაკუთრებით მჭიდროდ დასახლებულ სანაპირო რაიონებში, რამაც ხელი შეუწყო სასმელი წყლით მომარაგების რეგულარობის გაუმჯობესებას და მიწისქვეშა წყლების რესურსებსა და კაშხლებზე დამოკიდებულების შემცირებას, განსაკუთრებით გვალვის პერიოდებში. შედეგებმა ასევე აჩვენა, რომ გაუმართლებელი წყალი ეროვნული წყლის ნაზავის ძირითად რესურსად იქცა და ხელი შეუწყო წყლის კრიზისის სიმძიმის შემსუბუქებას რამდენიმე სანაპირო პროვინციაში. მეორეს მხრივ, კვლევამ გამოავლინა მთელი რიგი გამოწვევები, რომლებიც ზღუდავს გაუმართლების ეფექტურობას, როგორც ყოვლისმომცველ და მდგრად გადაწყვეტას, მათ შორის უპირველეს ყოვლისა არის მაღალი საინვესტიციო და საოპერაციო ხარჯები, ტრადიციულ ენერჯიაზე ძლიერი დამოკიდებულება, მარილწყლის ჩაშვებით გამოწვეული გარემოზე ზემოქმედება, ასევე გაუმართლებელი წყლის შეზღუდული გადატანა შიდა რაიონებში. კვლევამ დაასკვნა, რომ ზღვის წყლის გაუმართლება წარმოადგენს მნიშვნელოვან სტრატეგიულ ვარიანტს ალჟირში წყლის უსაფრთხოების გასაძლიერებლად, მაგრამ ის თავისთავად საბოლოო გადაწყვეტას არ წარმოადგენს. პირიქით, ის უნდა იყოს ინტეგრირებული ყოვლისმომცველ ეროვნულ ხედვაში, რომელიც დაფუძნებულია წყლის წყაროების დივერსიფიკაციაზე, მოხმარების რაციონალიზაციაზე, წყლის მართვის გაუმჯობესებასა და განახლებად ენერჯიაზე დამოკიდებულების გაზრდაზე, რითაც უზრუნველყოფილი იქნება მდგრადი წყლის უსაფრთხოების მიღწევა გრძელვადიან პერსპექტივაში.

**JEL კლასიფიკაცია:**

მიღებულია:

09.01.2026

რეგენზირებულია:

14.02.2026

დამტკიცებულია:

07.04.2026

Q25, Q54, Q56, H54, O13

<https://doi.org/10.46361/2449-2604.13.1.2026.44-59>

**Introduction and review of literature**

In recent decades, the world has witnessed a rapidly growing problem of water scarcity, which has begun to threaten the stability of populations and their economic and social security. This has made water security a key

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focus in the development policies of countries. Water is no longer merely a naturally available resource; it has become a strategic element closely linked to achieving food security, the prosperity of industrial and service sectors, and ensuring environmental balance. The severity of this issue has increased due to multiple factors, most notably climate change, the degradation of traditional resources, rapid population growth, and unbalanced urban expansion, prompting the international community to seek innovative solutions to ensure the fulfillment of current and future needs for this vital resource.

Algeria is one of the countries facing significant challenges in the field of water resources, as it is classified among dry and semi-dry regions that suffer from limited natural water reserves. The water crisis is manifested in fluctuating rainfall, heavy reliance on surface and groundwater resources that are at risk of depletion, as well as the geographic imbalance in water distribution between the more humid northern coastal areas and the extremely arid southern desert. The pressure on water has intensified during the period between 2010 and 2025 due to population growth and improved living standards, which has multiplied the demand for water for domestic, agricultural, and industrial use, leading to a widening gap between supply and demand.

In light of this reality, Algeria has adopted an ambitious national strategy aimed at enhancing water security by diversifying supply sources. Desalination of seawater has been one of the most promising solutions, especially given that the country has a long coastline of over 1,200 km along the Mediterranean Sea. This approach has seen significant development over the past two decades through the establishment of several major desalination plants distributed across various coastal provinces such as Algiers, Oran, Tipaza, Mostaganem, Tamanrasset, and others, with the goal of ensuring the provision of drinking water to the residents of these areas and reducing reliance on dwindling groundwater resources.

This study focuses on analyzing the role of seawater desalination plants in achieving water security in Algeria during the period 2010-2025, by evaluating their contribution to meeting water demand, identifying the challenges they face, and the future opportunities available for their development. The study also aims to highlight the effectiveness of public policies in supporting desalination projects as a strategic option for water security, especially in light of climate change, rising temperatures, and the decline of traditional resources. This analytical approach seeks to provide a scientific perspective that enables a deeper understanding of the position of desalination within the national water system and contributes to guiding decision-makers towards enhancing sustainability and achieving comprehensive water security in Algeria.

#### **Significance of the Study:**

The importance of studying the role of seawater desalination plants in achieving water security in Algeria lies in their ability to provide a realistic analysis of these facilities' contribution to addressing water challenges during the period 2010–2025. In years characterized by an increasing frequency of droughts, the impacts of climate change, and rising water demand, the study highlights the economic, social, and environmental dimensions of desalination projects. It assesses their efficiency and effectiveness in meeting the needs of the population and productive sectors while exploring the technical and regulatory challenges they face. This study helps provide accurate scientific data for decision-makers to improve water planning, support integration between different water sources, and enhance sustainability and resilience in the national water infrastructure, ensuring the achievement of long-term water security.

#### **Objectives of the Study:**

This study aims to achieve a set of scientific objectives focused on analyzing the reality of water security and the role of desalination plants in supporting it. The objectives can be summarized as follows:

- Analyze the reality of water security in Algeria during the period 2010-2025 and identify the main challenges it faces.
- Study the development of seawater desalination plants in Algeria in terms of their number, production capacity, and geographical distribution.

- Assess the extent of desalination plants' contribution to covering the water deficit, especially in densely populated coastal areas.
- Observe the relationship between the expansion of desalination projects and the achievement of water security, and evaluate the effectiveness of these projects in mitigating water crises.
- Analyze the economic and environmental aspects of seawater desalination in the Algerian context and the long-term sustainability of this option.
- Propose practical recommendations to improve the performance of desalination plants and enhance their role within a comprehensive national strategy to achieve water security.

#### **Justifications for choosing the period (2010 – 2025)**

The selection of the period (2010–2025) is based on several considerations that can be explained as follows:

- **The beginning of actual expansion in establishing desalination plants:** Since 2010, Algeria has shown a clear tendency to adopt seawater desalination as a strategic option to address water shortages, with the government beginning to inaugurate large plants in several coastal provinces.
- **Significant climatic changes:** This period was marked by increased drought severity and climate changes, which intensified pressure on conventional water resources and highlighted the importance of seeking alternative sources such as desalination.
- **Increasing water demand:** The population grew significantly during this period, alongside the expansion of cities and agricultural and industrial projects, which increased water consumption, especially in coastal areas.
- **Availability of recent data and statistics:** The chosen period spans more than 15 years, providing a wealth of data and statistics for analysis, including the assessment of desalination plants' performance and their role in supporting water security.
- **Clear national plans and strategies:** During this period, several national programs and plans were launched within the framework of water policy, most notably the "National Water Security Plan," which includes water desalination projects.
- **The end of the period represents a milestone for interim evaluation:** The year 2025 serves as a horizon for the interim assessment of the state's policies in the water sector, with the expectation of issuing evaluation reports and a new national strategy, making it an appropriate point to conclude the study.

#### **Research Problem**

Algeria has faced significant challenges in achieving water security over recent decades due to increasing water demand and the decline of traditional resources as a result of climate change and drought. In this context, the state has turned to investing in seawater desalination plants as a strategic option to support water supply, especially in coastal areas. However, the effectiveness of this option in enhancing long-term water security still requires study and analysis. Accordingly, the problem centers around the following question:

**To what extent do seawater desalination plants contribute to achieving water security in Algeria during the period 2010–2025?**

#### **Sub-questions:**

Based on the issue raised, the sub-questions of the study can be formulated as follows:

- 1- What is the current state of water security in Algeria during the period 2010-2025?
- 2- How have seawater desalination projects and plants developed in Algeria during this period?
- 3- To what extent do desalination plants contribute to meeting water demand in coastal areas?
- 4- What challenges does Algeria face in using desalination as a permanent solution to the water crisis?
- 5- How effective are government policies in supporting desalination to achieve water security?

6- What are the future prospects for seawater desalination in Algeria in light of climate changes and population pressure?

**Research Hypotheses:**

In light of the previous questions and to guide the course of the study and analyze its variables, the following hypotheses were formulated:

**Hypothesis One:** Water security in Algeria during the period 2010-2025 is likely to have improved relatively in some coastal areas, despite the continued imbalance between water resources and increasing demand.

**Hypothesis Two:** It is expected that seawater desalination projects in Algeria have seen significant expansion during this period, both in terms of the number of plants and their production capacity.

**Hypothesis Three:** Seawater desalination plants are likely to have contributed effectively to meeting a considerable portion of water needs, especially in coastal cities suffering from a shortage of conventional resources.

**Hypothesis Four:** Algeria is assumed to face a range of technical, financial, and environmental challenges that limit the adoption of desalination as a permanent and comprehensive solution to the water crisis.

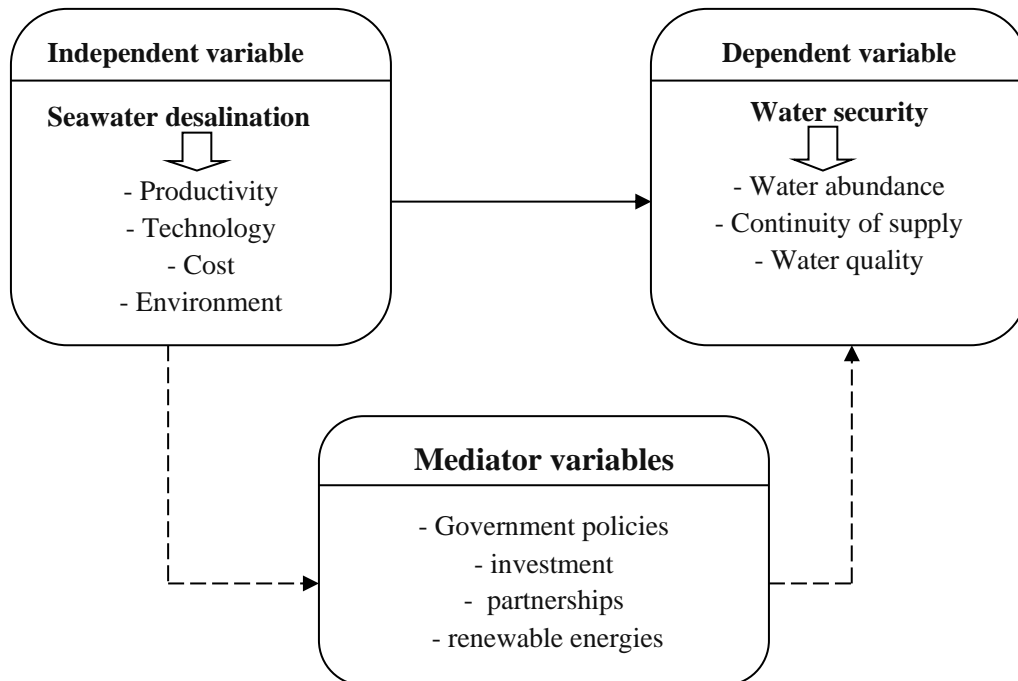
**Hypothesis Five:** Government policies supporting desalination may be relatively effective in enhancing water security, but they still require further integration and development to ensure the sustainability of resources.

**Hypothesis Six:** Expectations indicate that the future prospects for seawater desalination in Algeria are promising, especially with the increasing reliance on modern technology, despite the risks associated with climate change and demographic pressure.

**Study Model**

In light of the study problem and its research objectives, and for the purpose of clarifying the relationships between the studied variables, the following conceptual model was adopted:

**Figure 1.** Study Model



Source: Prepared by the researcher

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The proposed study model represents the methodological framework that outlines the research path on the role of seawater desalination plants in achieving water security in Algeria during the period 2010-2025. The model starts from the independent variable represented by seawater desalination plants, considering them one of the most important strategic options adopted by Algeria to reduce water scarcity and enhance non-conventional water resources, especially in densely populated coastal areas. The impact of this variable is reflected through its operational, technical, energy-related, and productive dimensions on the dependent variable represented by water security, which includes water availability, supply continuity, and the quality of water provided to citizens.

The model also highlights the role of a set of mediator variables that work to strengthen this relationship, including supportive government policies, necessary investments, partnerships with the public and private sectors or with international companies, as well as the use of renewable energies to ensure the sustainability and efficiency of desalination.

This model links its elements through a series of causal relationships that the study seeks to analyze and measure based on available data and water indicators, allowing for a deeper understanding of the contribution of desalination plants in addressing the water deficit problem in Algeria and enhancing the state's strategic capacity to cope with climate fluctuations and future population pressures.

### **Methodology**

This study relied on the descriptive-analytical approach as it is considered the most suitable for the nature of the topic. It aims to describe the reality of water security in Algeria and analyze the role of seawater desalination plants in supporting it during the period 2010-2025. This approach is based on collecting data and information related to desalination plants, such as their number, production capacity, and geographical distribution, and then analyzing this data to reveal the extent of their contribution to covering the water deficit and meeting the increasing demand for water. This approach also allows for understanding the correlation between the expansion of desalination projects and national policies aimed at achieving water security, without intervening in the variables but studying them as they exist in reality.

#### **1- The Concept of Water Security**

Water security is considered a vital issue directly linked to the sustainability of human life and economic growth, as it ensures the availability of water in adequate quantity and quality for all uses. This concept is central in national and regional planning to address future environmental and social challenges. To provide a comprehensive understanding of water security, we present below the various definitions provided by researchers, highlighting the fundamental components of the concept and ways to achieve it:

Water security is "a state in which countries ensure the ability to provide an adequate quantity of water with suitable quality for all uses while guaranteeing environmental sustainability." (Ahmed, 2020)

Water security is defined as "the continuous access to clean and usable water to meet the needs of individuals and communities." (Laila, 2019)

Water security means "the ability to manage water resources effectively so that risks related to water scarcity and drought are minimized." (Sami, 2021)

It is "a state of balance between water demand and available resources, with the ability to face environmental, social, and economic challenges associated with water." (Al-Zahraa, 2018)

To clarify how water security is measured and analyzed within the study framework, it refers to the ability of a country or community to ensure the availability and quality of sufficient water over time to meet the needs of the population and economic activities, while preserving the environment, as well as the ability to manage water resources sustainably to address future challenges such as climate change and population growth.

#### **2. The Concept of Water Desalination:**

Water desalination is considered one of the essential technologies for ensuring water security in areas suffering from resource scarcity, as it provides water suitable for human, agricultural, and industrial use. The following are the various scientific definitions of this concept as found in the specialized literature:

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Water desalination is "the process of treating saline water, especially seawater, with the aim of removing salts and impurities from it, making it suitable for human consumption and various uses such as agriculture and industry, in order to meet water needs in areas suffering from scarcity." (Al-Shammari, 2020)

Water desalination is "a set of physical and chemical processes, such as thermal distillation and reverse osmosis, aimed at separating dissolved salts and inorganic materials from water to achieve water quality that meets approved health standards." (Al-Karaghoulis & Lawrence, 2013)

Water desalination "represents a strategic option in water resource management, relying on the use of non-traditional resources to enhance water security and support sustainable development in countries facing increasing pressure on freshwater resources." (United Nations, 2021)

To define the methods for measuring and analyzing water desalination within the framework of the study, it refers to the process through which fresh water suitable for human consumption is produced in Algeria during the studied period. This is achieved by removing salts, minerals, and impurities from seawater using approved techniques such as reverse osmosis and distillation, with the aim of supporting water security and meeting the needs of various sectors. It is measured through quantitative indicators including: the annual volume of desalinated water produced, the number of active desalination plants, the proportion of desalinated water's contribution to total water resources, and production and distribution costs.

### **3. Advantages of Water Desalination**

Water desalination offers numerous advantages that contribute to achieving water security and supporting sustainable development. These include improving water availability and quality, reducing pressure on traditional resources, keeping up with population and economic growth, benefiting from modern technologies, and adapting to climate changes. The main advantages of this process are highlighted as follows:

- Enhancing water security by providing a sustainable water source in areas facing freshwater scarcity. (United Nations, 2021)
- Reducing pressure on traditional resources such as groundwater and surface water, which are subject to depletion and pollution. (Shammari, 2020)
- Keeping up with demographic and urban growth by providing the necessary water for populations, industry, and services. (Ghaffour, Thomas, & Gary, 2013)
- Improving water quality to be safe and suitable for drinking according to global health standards. (Al-Karaghoulis & Lawrence, 2013)
- Supporting economic development, as water availability facilitates investment in tourism, industry, and irrigation-dependent agriculture. (World Bank, 2017)
- Protection from the effects of climate change and drought by relying on a resource that is not affected by rain and rivers. (Semiat, 2008)
- Benefiting from modern technologies in a way that drives innovation in the fields of energy and desalination and reduces future operational costs. (Nejem, 2018)

### **4. Water Desalination Challenges**

Despite the important role of water desalination in enhancing water security, this process faces a number of technical, economic, and environmental challenges, which require effective strategies to manage and ensure resource sustainability. The main challenges of water desalination include:

- High capital and operational costs due to the need for advanced technologies and high energy consumption. (Thomas, Gary, & Ghaffour, 2013)
- The negative environmental impact resulting from the discharge of concentrated brine into the sea and the threat it poses to the marine ecosystem. (United Nations, 2021)
- Heavy reliance on fossil energy in many countries, which increases carbon emissions and deepens energy dependence. (Semiat, 2008)

- The continuous need for maintenance and advanced technologies due to equipment corrosion and membrane fouling in reverse osmosis plants. (Al-Karaghoulis & Lawrence, 2013)
- Limited capacity to meet the needs of inland areas far from the coast due to transportation costs and distribution infrastructure. (World Bank, 2017)
- Institutional and legislative challenges related to activating investment, regulating the sector, and ensuring sustainable financing. (Nejem, 2018)

### 5. Key Water Desalination

Technologies Several technologies are available for water desalination, differing in terms of efficiency, cost, and energy consumption, and are used depending on the nature of the saline water and consumption needs. The most prominent of these currently used technologies are as follows:

**5.1 Reverse Osmosis:** Currently the most widely used technology, it relies on using fine membranes to separate salts under high pressure. It is characterized by lower operating costs compared to thermal methods. (Al-Karaghoulis & Lawrence, 2013)

**5.2 Multi-Stage Flash Distillation:** A thermal technology that involves heating saline water and evaporating it gradually through multiple stages, then condensing the vapor to obtain fresh water. (Ghaffour, Thomas, & Gary, 2013)

**5.3 Multi-Effect Distillation:** Based on a series of heat exchangers, where the vapor generated from each stage is used to heat the following stage to reduce energy consumption. (Ghaffour, Thomas, & Gary, 2013)

**5.4 Electrodialysis Desalination:** Relies on passing an electric current to separate salts through selective membranes, and is often used for water with medium salinity. (Semiat, 2008)

**5.5 Solar-powered water desalination:** Techniques that rely on renewable energy to reduce costs and emissions, including solar reverse osmosis and solar evaporation. (Nejem, 2018)

### 6. Global Water Security Indicators

International studies in the field of water security are based on a set of globally recognized indicators that help measure the availability, quality, and sustainable management of water resources. The most prominent of these indicators include:

- Water Stress Index, which measures the proportion of withdrawals from renewable water resources and indicates the level of pressure on available resources. (Gleick, 1993) (World Bank, 2017)
- Percentage of the population served with safe drinking water, considered a critical indicator in assessing the social dimension of water security. (United Nations, 2021)
- Water Quality Index, which measures the degree of pollution in water resources and their compliance with health and environmental standards. (World Health Organization, 2017)
- Integrated Water Resources Management Index, which is related to the effectiveness of legislation and governance in regulating the water sector. (Global Water Partnership, 2000)
- National Water Security Index, which combines the dimensions of availability, quality, economic, and ecological capacity into a comprehensive assessment of the water situation in each country. (UNESCO, 2021)

### 7. The Reality of Water Security in Algeria

Data indicate that Algeria is facing severe water stress as a result of a combination of scarce natural resources and increasing population and economic demand. Overall, renewable water resources are estimated at about 11.67 billion m<sup>3</sup> per year (surface and groundwater) (Food and Agriculture Organization (FAO), 2024) This figure amounts to less than 300 m<sup>3</sup> per person per year, which is lower than many countries considered to be below the 'water poverty line' (1,000 m<sup>3</sup> per person/year) according to World Bank standards. On the other hand, the geographical distribution of resources is uneven: the coastal and northern regions, which receive higher rainfall, account for most of the available resources, while the interior and desert areas suffer from structural

water scarcity due to very low rainfall (less than 100 mm in some desert areas) and weak groundwater replenishment. (SDG6 Data, 2023)

On the demand side, Algeria is witnessing a continuous increase due to population growth, urban expansion, and the shift of some economic sectors towards higher water consumption. It is estimated that demand has doubled or increased significantly over the past decades, approaching half of the potentially mobilizable resources, especially when considering the volume of groundwater withdrawals, which is not always closely monitored. The agricultural sector also consumes the largest share of national water, generating increasing competition between domestic, industrial, and agricultural uses, and weakening the state's ability to overcome moments of water crisis. (Water Fanack, 2023)

The infrastructure and national projects reflect an awareness of the issue: a number of dams and desalination plants have been developed, and water treatment and reuse have begun in some models. However, implementation and distribution remain insufficient in the face of increasing challenges. For example, the report indicates that desalination capacity has increased but still represents only part of the solution, while many areas suffer from interruptions or irregular supply, leading to local protests in the affected provinces. (The Guardian, 2024)

In conclusion, the reality of water security in Algeria is a mix of limited potential, increasing demand, and regulatory, geographical, and climatic challenges. While measures are underway, their implementation needs to be accelerated, governance improved, the reuse of non-conventional resources enhanced, and better distribution and more efficient management of water resources pursued, so that desalination and other projects can effectively and sustainably support water security.

#### **8. Water Challenges in Algeria During the Period 2010-2025**

Algeria faced significant water challenges during the period between 2010 and 2025, which impacted sustainable development and food security. These challenges were exacerbated by climate change, population growth, and the deterioration of water infrastructure. The most prominent of these challenges include:

**8.1 Water scarcity and declining per capita share:** Algeria is considered a water-scarce country, with the per capita share of freshwater not exceeding 500 cubic meters per year, which is much lower than the recommended global average, placing the country among those at risk of a severe water crisis. (Fanack Water, 2019)

**8.2 Deterioration of infrastructure and high leakage rates:** Water distribution networks suffer from aging and deterioration, leading to the leakage of large quantities of water. Some studies indicate that leakage rates may reach up to 35% in certain areas, increasing pressure on limited resources. (Ministry of Interior Algeria, 2024)

**8.3 Water pollution and quality deterioration:** Water sources are exposed to pollution from industries, agriculture, and household waste, which negatively affects water quality and makes treatment more difficult, thus posing a threat to public health. (World Bank, 2018)

**8.4 Climate change and its impact on resources:** Climate fluctuations have led to changes in rainfall distribution, affecting water availability. Experts indicate the possibility of a further decline in water resources in the coming years. (Fanack Water, 2019)

**8.5 Increasing water demand:** Water demand is rising due to population growth, urban expansion, and increased industrial activities, requiring significant investments in infrastructure to meet the needs of the population and economic sectors. (Fanack Water, 2019)

**8.6 Uneven distribution of resources:** It is observed that water distribution among different sectors (agricultural, industrial, domestic) is uneven, leading to resource depletion in some areas and reduced efficiency in its use. (Fanack Water, 2019)

**8.7 Investment in unconventional resources:** Algeria has resorted to investing in unconventional water resources, such as seawater desalination and the reuse of treated water. However, these projects require advanced technologies and significant investments to ensure their sustainability. (Fanack Water, 2019)

#### **9. The Development of Desalination Plants in Algeria (2010-2025)**

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In light of the increasing challenges facing water resources in Algeria, especially with the decline in rainfall and the growing demand for drinking water due to population growth and urban expansion, seawater desalination has emerged as one of the strategic solutions to ensure national water security. Algeria's reliance on this non-traditional resource has shifted from being a secondary, limited-impact option to a fundamental pillar in the country's water policy. The development in the number of desalination plants and their production capacities over recent years reflects the significant shift in the government's vision towards diversifying water sources and reducing dependence on dams and groundwater. The following table shows the different stages of the development of seawater desalination plants in Algeria, in terms of the number of plants, their production capacities, and their geographical distribution over various time periods.

**Table 1.** Development of Desalination Plants in Algeria (2010-2025)

Time period	Number of stations	Approximate production capacity	Major stations/states	Main observations
<b>Before 2010</b>	5–6 stations	Less than 300,000 m <sup>3</sup> /day	Algiers, Oran, Arzew	Weak reliance on desalination, focus on dams and groundwater
<b>2010 – 2015</b>	11 stations	About 2.1 million m <sup>3</sup> /day	Hamma (Algeria), El Maktab (Oran), Beni Saf	Beginning of a strategic reliance on desalination to secure drinking water
<b>2016 – 2020</b>	12 stations	Stable at 2.1 million m <sup>3</sup> /day	The same stations with improved performance	Slowdown in investment, high operating costs
<b>2021 – 2023</b>	12 stations + rehabilitation	About 2.2 million m <sup>3</sup> /day	Restarting and upgrading old stations	Recurring drought highlights the importance of desalination
<b>2024 – 2025</b>	17 stations	More than 3.7 million m <sup>3</sup> /day	El Tarf, Bejaia, Boumerdes, Tipaza, Oran	New plants with a capacity of 300,000 m <sup>3</sup> /day per plant
<b>Prospects 2030</b>	+25 stations (expected)	5–6 million m <sup>3</sup> /day	Jijel, Skikda, Tizi Ouzou, Mostaganem	Desalination covers 40–60% of drinking water

**Source:** Data were compiled from reports issued by the Algerian Ministry of Water Resources and Water Security, as well as official publications and press reports concerning seawater desalination projects in Algeria.

The table clearly shows that the development trajectory of desalination plants in Algeria has gone through several distinct phases. The first phase, before 2010, was characterized by limited reliance on desalination, with low production capacities that could only cover a small fraction of the demand for drinking water. However, the period between 2010 and 2015 marked a real turning point, during which major plants with significant production capacity were established, allowing the contribution of desalinated water to the national water mix to increase. Despite a relative stability observed during the 2016–2020 period, the repeated drought waves after 2021 pushed desalination back to the forefront of strategic options, which was reflected in the launch of an ambitious program to build new high-capacity plants during 2024–2025. The outlook for 2030 indicates a clear trend toward strengthening reliance on desalination as a sustainable source, with a notable portion of drinking water needs

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expected to be met, reflecting Algeria’s transition to a more flexible and sustainable model in managing its water resources.

**10. Prospects for Developing a National Sustainable Strategy for Seawater Desalination in Algeria**

Seawater desalination is considered one of the fundamental pillars for achieving water security in Algeria, especially in light of the increasing demand for water due to population growth, urban expansion, and industrial development. From this standpoint, the state is working to establish a national sustainable strategy to develop this vital sector, integrating technological innovation, resource use efficiency, and environmental protection. This strategy aims to expand the capacity of desalination plants, improve the quality of produced water, and reduce operating costs, while ensuring the sustainability of the marine environment and minimizing the carbon footprint of operations. The following table highlights the main strategic axes and the prospects for their national development, reflecting a comprehensive vision to enhance long-term water security:

**Table 2.** Prospects for Developing a Sustainable National Strategy for Seawater Desalination in Algeria

Strategic Axis	Axis Content	Main Objectives	Expected Impact
<b>Water strategic planning</b>	Integrating desalination into the national water security strategy and linking it to future demand forecasts	Ensuring continuity of water supply and reducing drought risks	Enhancing water security and social stability
<b>Energy sustainability</b>	Relying on renewable energies to operate desalination plants (solar and wind)	Reducing energy costs and lowering emissions	Improving economic and environmental feasibility
<b>Institutional governance</b>	Improving plant management, enhancing transparency, and expanding public-private partnerships	Improving performance efficiency and ensuring financial sustainability	Improving the effectiveness of the national strategy
<b>Environmental dimension</b>	Adopting environmentally friendly technologies for brine disposal and monitoring environmental impact	Protecting the marine and coastal environment	Achieving a balance between development and environmental protection
<b>Scientific research and innovation</b>	Supporting research and development and localizing desalination technology	Enhancing technological independence	Long-term sustainability and reducing external dependency
<b>Human resource development</b>	Training national competencies in desalination and technical management	Improving operation and maintenance quality	Improving service continuity
<b>International cooperation and experiences</b>	Benefiting from leading international experiences and transferring technology	Enhancing performance and preventing errors	Accelerating the development of the national strategy
<b>Spatial justice</b>	Expanding networks for transporting desalinated water to inland areas	Reducing regional disparities in water supply	Enhancing regional cohesion

**Source:** Prepared by the researcher based on: (Merabet, 2024) (Fanack Water, 2019)

The table outlines the main strategic axes for the development of seawater desalination in Algeria, detailing the content of each axis and the objectives associated with it. It can be observed that the national strategy focuses on several key dimensions, including strengthening the infrastructure of desalination plants, adopting advanced technologies to improve production efficiency and reduce energy consumption, and ensuring the quality of produced water according to international health standards. The strategy also aims to integrate innovation and modern technology with the protection of the marine environment, and to encourage public-private partnerships

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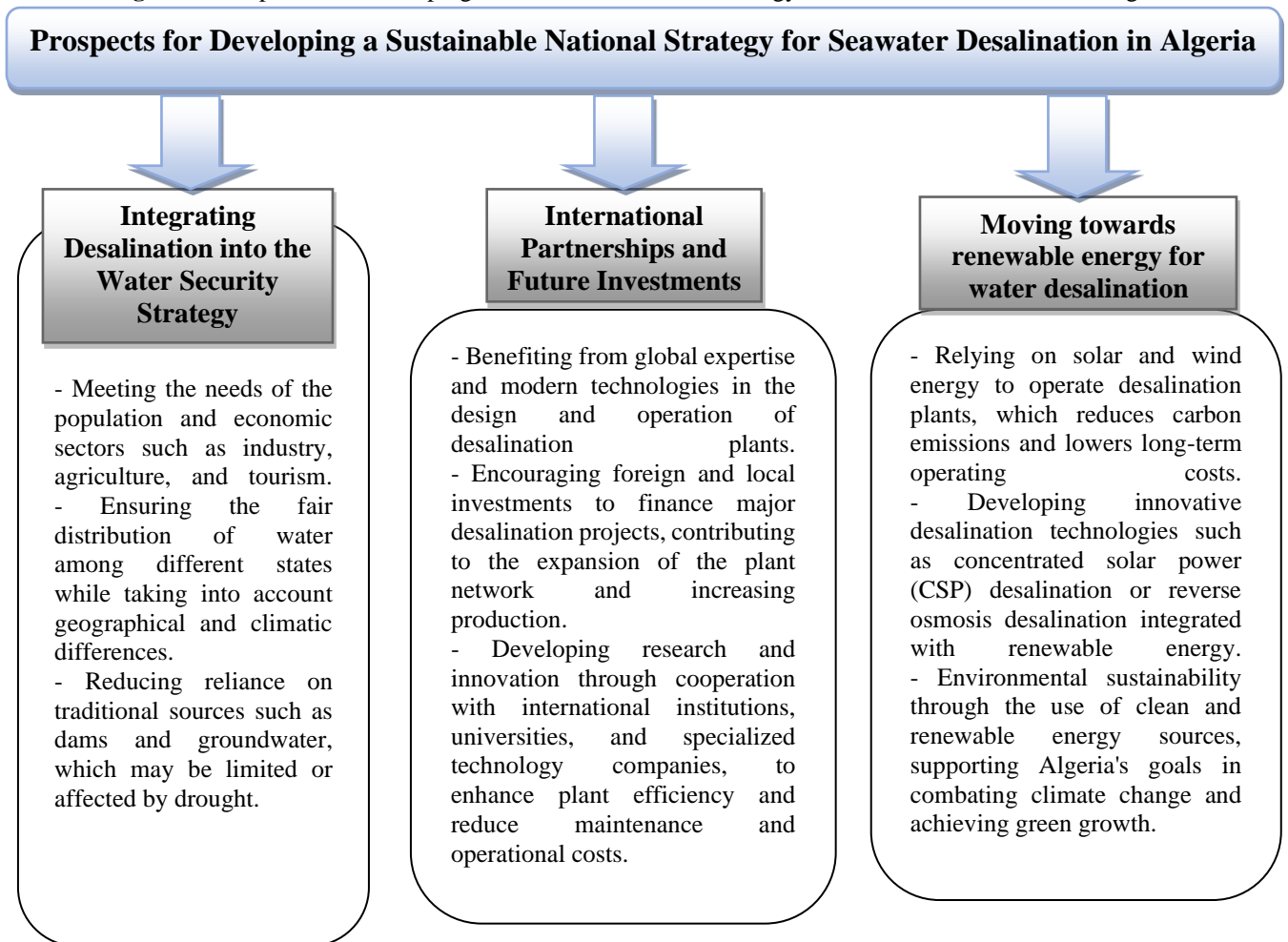


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to sustainably finance desalination projects. The table reflects a comprehensive vision that seeks to achieve long-term water security across different regions of the country, while maintaining a balance between economic development and the preservation of natural resources.

Despite the prospects outlined in the previous table, there are other opportunities that can be added to develop a sustainable national strategy for seawater desalination in Algeria, including integrating desalination within the water security strategy, moving towards renewable energy for water desalination, and future international partnerships and investments. These new areas complement the national strategic vision and contribute to enhancing water security and achieving long-term resource sustainability. The following figure illustrates these prospects:

**Figure 2.** Prospects for Developing a Sustainable National Strategy for Seawater Desalination in Algeria



**Source:** Prepared by the researcher based on: (World Bank, 2017) (Semiat, 2008) (Nejem, 2018) (UNESCO, 2021)

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The accompanying figure illustrates the three main axes for developing a national sustainable strategy for seawater desalination in Algeria, which are: integrating desalination within the water security strategy, moving towards renewable energies, and international partnerships and future investments. The figure highlights, in a simplified manner, the relationship between these axes and their importance in enhancing water security and achieving long-term environmental and economic sustainability.

**11. Analysis of Results and Discussion of Hypotheses**

After presenting the theoretical framework and analyzing the data related to the state of water security and the development of seawater desalination projects in Algeria during the period (2010–2025), this study aims to test the hypotheses formulated in light of the research problem and its sub-questions. This section aims to assess the validity of these hypotheses by analyzing the results obtained and linking them to the national water context, which allows for identifying the actual role of seawater desalination in enhancing water security and revealing the main challenges and future prospects associated with this strategic option.

**Table 3. Results of the Study Hypotheses Test**

Hypothesis Number	Hypothesis Text	Test Result	Interpretation Summary
<b>First hypothesis</b>	Water security in Algeria during the period (2010–2025) likely experienced relative improvement in some coastal areas, despite the continued imbalance between water resources and increasing demand.	Partial Acceptance	There has been a relative improvement in water security in coastal areas thanks to desalination, while pressure on traditional resources continues and the gap between supply and demand at the national level is widening.
<b>Second hypothesis</b>	It is expected that seawater desalination projects in Algeria expanded significantly during this period, both in terms of the number of plants and their production capacity.	Full Acceptance	The desalination sector has witnessed significant expansion in terms of the number of plants and production capacities, as part of diversifying water sources.
<b>Third hypothesis</b>	Seawater desalination plants likely contributed effectively to meeting a considerable portion of water needs, especially in coastal cities.	Full Acceptance	Desalinated water has become a key resource for supplying coastal cities, contributing to better distribution regularity and reducing disruptions.
<b>Fourth hypothesis</b>	Algeria is assumed to face technical, financial, and environmental challenges that limit the adoption of desalination as a permanent and comprehensive solution to the water crisis.	Full Acceptance	High costs, reliance on conventional energy, and environmental impacts pose obstacles to making desalination a definitive solution.
<b>Fifth hypothesis</b>	Government policies supporting desalination may be relatively effective in enhancing water security, but they require further integration and development.	Partial Acceptance	Public policies have supported desalination, but limited coordination with demand management and resource protection has reduced its long-term effectiveness.
<b>Sixth hypothesis</b>	Forecasts indicate that the future prospects for seawater desalination in Algeria are promising despite climatic and demographic challenges.	Full Acceptance	The future of desalination is promising in light of technological advancements, provided that economic and environmental sustainability is ensured.

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**Source:** Prepared by the researcher based on the statistical data and the descriptive analysis of the study.

**Note:** The acceptance of the hypotheses (fully/partially) was determined based on the analysis results and their compatibility with water security indicators and the development of seawater desalination projects.

This table shows that most of the study's hypotheses have been fully or partially accepted, highlighting the growing role of seawater desalination in enhancing water security in Algeria, while emphasizing the continued need for an integrated approach that combines desalination, consumption rationalization, and proper management of water resources to achieve long-term water sustainability.

## 12. Discussion of the results

The results of the hypothesis test show that seawater desalination represents one of the key pillars of Algerian water policy during the period (2010–2025). However, its role cannot be understood in isolation from the general context of water security, which is characterized by structural complexities linked to the scarcity of traditional resources, climate change, and rapid population growth. The results confirmed a relative improvement in water security, especially in coastal areas, which aligns with the theoretical proposition that considers desalination an unconventional resource capable of reducing dependence on rainfall and dams. Nevertheless, this improvement remained limited in terms of its comprehensiveness and sustainability.

The results also showed that the expansion in the number of desalination plants and their production capacity reflects a clear political will to diversify water sources, which aligns with the experiences of Mediterranean and Arab countries that faced similar climatic conditions. However, this expansion, despite its importance, was not always accompanied by parallel developments in management efficiency, cost reduction, or the integration of renewable energy, which explains the persistence of some imbalances in water supply.

Regarding the contribution of desalination to meeting demand, the results indicated that desalinated water has become a primary resource in coastal cities, helping to improve supply regularity and reduce interruptions, especially during drought periods. Yet, the increasing reliance on desalination has revealed technical, environmental, and financial challenges, confirming that this option cannot be the sole solution to the water crisis.

At the level of public policies, the results have shown a relative effectiveness of government intervention in supporting desalination projects. However, the limited coordination between supply policies (desalination) and demand management policies, coupled with weak integration with strategies for protecting water resources, reduces the long-term impact of these policies. Thus, the study's findings confirm that the success of desalination is linked to the extent to which it is integrated into a comprehensive and sustainable vision for water security.

## 13. Conclusion

In conclusion, this article, which discussed the role of seawater desalination plants in achieving water security in Algeria during the period 2010–2025, confirms that the issue of water security has become one of the most urgent strategic concerns in light of increasing climate change, the limited traditional water resources, and the rapid population and economic growth. This study aimed to analyze the reality of water security in Algeria and evaluate the extent to which seawater desalination, as a non-traditional option, contributes to addressing water shortages and achieving some stability in water supply, especially in coastal areas.

The study results showed that Algeria has made significant progress in the field of seawater desalination during the period studied, both in terms of the number of completed plants and the installed production capacity, which positively impacted the improvement of potable water supply in several major coastal cities. The hypothesis testing results also confirmed that seawater desalination has become a key pillar in national water policy and has effectively contributed to mitigating water crises and reducing excessive reliance on surface and groundwater resources. However, this improvement remained relative and incomplete, as the imbalance between water supply and demand continued, particularly in inland areas. Several technical, financial, and environmental challenges also emerged, limiting the consideration of desalination as a definitive and sustainable solution on its own.

In light of these results, the study concluded that seawater desalination represents a complementary rather than a total alternative solution, and its effectiveness in achieving water security remains contingent upon its

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integration into a comprehensive national strategy that considers water demand management, distribution efficiency improvement, protection of conventional resources, and the enhancement of water governance.

Based on this, the study proposes a set of recommendations, most notably:

- The necessity of integrating seawater desalination into a comprehensive national vision for water security, based on diversifying sources and rationalizing consumption.
- Enhancing reliance on renewable energies, particularly solar energy, in the operation of desalination plants to reduce costs and minimize environmental impacts.
- Improving institutional governance of the water sector by increasing management efficiency, supporting transparency, and developing partnerships between the public and private sectors.
- Expanding networks for transporting desalinated water to inland areas to reduce regional disparities in supply.
- Supporting scientific research and localizing desalination technology, while investing in the training of specialized national human resources.

As for the future prospects, the study indicates that the future of seawater desalination in Algeria looks promising, especially with the move towards building new plants with higher production capacities, adopting more efficient and energy-saving technologies, as well as the growing opportunities for international cooperation and partnerships in this field. However, achieving these prospects remains dependent on the state's ability to face climatic and economic challenges and ensure the long-term sustainability of projects.

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