2026, Cilt 3, Sayı 3, 308-319

OPEN ACCESS

ISSN: 3062-262X

Akademik Eğitim ve Sosyal Bilimler Dergisi (AJESS Journal)

Water Security: A Key Driver of Food Security and Agricultural Development in Algeria

Nour El Houda Lakhder, Abdelhamid Mehri University – Constantine 2 (Algeria), Laboratory of Economics and Management (LABECOM), nourelhouda.lakhdar98@gmail.com ; ORCID ID: https://orcid.org/0009-0004-1190-3843

Oualid Hamdi Pacha, Scientific and Technical Research Center for Arid Regions C.R.S.T.R.A (Algeria), oualid.hamdipacha@mail-crstra.dz; ORCID iD: https://orcid.org/0009-0004-5292-0850

Zine Aissa, University of El-Oued, zine-aissa@univ-eloued.dz ; ORCID ID: https://orcid.org/0009-0002-2565-9197

Tedjani Tahraoui, University of El-Oued, tedjani-tahraoui@univ-eloued.dz ; ORCID ID: https://orcid.org/0009-0006-7628-3854

Article History

Received: 31/07/2026 Accepted: 29/08/2026 Published: 05/09/2026

Abstract

This study analyzes the contribution of water security to meeting food security and agricultural development requirements in Algeria by examining the state of water resources, the main policies and strategies adopted for their mobilization and valorization, and their role in supporting agricultural activity and food security. The study adopts a descriptive-analytical approach based on data and information relating to water resources and water and agricultural policies in Algeria. The findings indicate that Algeria has made significant efforts to strengthen water security through dam construction, expanded seawater desalination, water-network development, wastewater treatment, and policies supporting the agricultural sector. Nevertheless, limited water resources, irregular rainfall, the country's arid and semi-arid climate, and growing water demand remain major constraints to sustainable water security. The study concludes that strengthening food security and agricultural development in Algeria depends substantially on integrated and sustainable water-resource management and improved water-use efficiency, particularly in agriculture.

Keywords: water security; food security; agricultural development; water resources; Algeria.
JEL Classification: Q25; Q18; Q15; O13.

Introduction

Water security has become one of the central issues in the path toward sustainable development, given that water resources constitute a fundamental input for the continuity of economic and social activities, foremost among them agricultural activity and food production. Water security is no longer measured merely by the availability of water resources; rather, it is linked to society's ability to ensure sustainable access to sufficient quantities of water of acceptable quality in a manner that supports livelihoods, well-being, and social and economic development, while preserving ecosystems and reducing water-related risks (UN-Water, 2013).

The importance of water security becomes more evident when it is linked to food security and agricultural development, given that water represents one of the most important factors of agricultural production and that its scarcity or inefficient use affects the agricultural sector's ability to maintain stable levels of production. Therefore, the relationship between water security and food security is not limited to the availability of water itself; it also extends to agricultural water productivity, the efficiency of irrigation systems, the sustainability of groundwater and surface-water exploitation, and the capacity of the agricultural sector to adapt to climate fluctuations.

This relationship is particularly important in Algeria, which is characterized by arid and semi-arid climatic conditions and increasing pressure on its water resources. The Food and Agriculture Organization of the United Nations indicates that Algeria suffers from severe water stress, exacerbated by climate change and population growth, and that the challenge is to increase agricultural production using less water, making water productivity a key element in building more sustainable and resilient agriculture (FAO, WaPOR).

In the same context, the issue of food security in Algeria cannot be separated from how water resources are managed and directed toward the most efficient agricultural uses. A specialized study on water resources and food security in Algeria concluded that water scarcity and increasing demand require reconsideration of water-resource management methods and of the options related to meeting food needs, reinforcing the importance of linking water policy with agricultural policy (Bouchentouf & Benabdeli, 2021).

Despite the diversity of water sources in Algeria and the adoption of policies and programs to mobilize them through dams, groundwater, seawater desalination, and wastewater treatment, continued pressures associated with population growth, increasing domestic, agricultural, and industrial needs, and climate fluctuations raise questions about the capacity of these resources and policies to achieve sustainable water security capable of supporting agricultural development and strengthening food security.

Research Problem:

Based on the foregoing, the research problem revolves around the following main question:

To what extent does water security contribute to meeting the requirements of food security and agricultural development in Algeria?

Research Hypothesis:

Based on the research problem, the study is based on the following main hypothesis:

Strengthening water security, through sound and integrated management of water resources, their mobilization, and rational use, contributes to supporting the requirements of food security and agricultural development in Algeria.

Importance of the Study:

The importance of the study stems from the strategic position occupied by water resources in supporting agricultural activity and achieving food security, particularly in light of the increasing pressures facing Algeria's water resources. The study is also important because it links the reality of water security, on the one hand, with the requirements of agricultural development and food security, on the other, highlighting the importance of sustainable and efficient water-resource management.

Objectives of the Study:

The study aims to analyze the contribution of water security to meeting the requirements of food security and agricultural development in Algeria; identify the state of water resources and Algeria's capacity to strengthen its water security; review the main policies and measures adopted for water-resource mobilization and management; and highlight the nature of the relationship between water security, food security, and agricultural development.

Methodology:

To achieve the study's objectives and answer its problem and questions, the descriptive-analytical approach was adopted by collecting and presenting data and information concerning the state of water resources, water security, and water and agricultural policies in Algeria, and then analyzing them to reveal the nature of the relationship between water security and the requirements of food security and agricultural development and to reach findings relevant to the subject of the study.

Structure of the Study:

To achieve the study's objectives and answer its problem, it was organized into two main sections. The first section addresses the theoretical framework of water security by presenting its concept, principal foundations, and determinants. The second section addresses water policy in Algeria and its relationship with economic development by analyzing the state of water security in Algeria, reviewing the water strategy and its implications for agriculture and food security, and then explaining the relationship between water security, food security, and agricultural development in Algeria.

Section One: Theoretical Introduction to Water Security

Achieving water security has become a major political challenge facing governments around the world, as the absence of significant reforms in the water sector and related policies may lead to a worrying outlook for several sectors. Nevertheless, achieving water security remains a challenge in light of increasing water demand, water stress, and pollution. From this perspective, it is important to briefly address the main concepts, foundations, and determinants associated with water security:

1- The Concept of Water Security

For a long time, the concept of water security remained associated with the military field and referred to armed invasion and conflict between states, reflecting power that could be coercively used and associated with military force or the deployment of destructive weapons. After the Cold War, the concept of water security expanded to include non-military dimensions (Bougrara & Abbassi, 2020, p. 5).

The term water security emerged to establish itself, particularly because water is one of the elements without which life cannot continue. Water security encompasses everything that enables knowledge of the state of water wealth in terms of reserves, diversity of sources, investment methods, quality improvement, and ensuring its availability in a manner that meets human consumption needs.

Water security has been defined as: "meeting water needs, quantitatively and qualitatively, continuously through protecting water, making good use of available water, developing tools and methods for such use, developing existing water resources, and searching for new resources." The UN Committee on Economic, Social and Cultural Rights has also defined it as: "the human right to water, which ensures that everyone has access to sufficient, safe, accessible, and affordable water for personal and domestic use" (Salhi, 2016, pp. 84–85).

Some define it as: "protecting the water resources available to any state from external threats, ensuring the continuity of these resources and freedom of their use according to national priorities and requirements, in addition to the ability to develop these water sources in accordance with renewed water needs in the foreseeable future and to develop them" (Al-Bassa & Dawoud, 2021, p. 4).

Some experts consider that the concept of water security should be based on water-balance indicators. Water balance refers to the process of balancing the total volume of traditional and non-traditional water resources (water supply) during a given period with the total volume of water needs required to meet different needs (water demand) during the same period. In other words, it identifies the quantities of water entering and leaving any water system. Water balance has three conditions (Ben Ghaida & Harkat, 2020, p. 554):

• Water balance: when water demand corresponds to the volume of water supplied.
• Water surplus: when the volume of water resources is greater than the volume of needs.
• Water deficit: when the volume of water resources is less than the amount required to meet necessary needs.

It can also be defined as the condition in which every person has an opportunity or ability to obtain clean and safe water, in sufficient quantity and at an appropriate price, so that they can live a life characterized by health, dignity, and productive capacity (Boukhaari & Ziar, 2020, p. 115), while preserving the ecosystems that provide water and simultaneously depend on it.

2- Foundations of Water Security

Water security expresses a situation characterized by the stability of water resources, in which water supply responds to demand. It rests on a number of foundations, without whose availability stability and sustainability cannot be achieved, as well as on the means (points) through which water security is achieved.

The following are the main foundations of water security (Al-Habiteri, 2017, p. 166):

• Considering water an economic commodity, meaning that it is not free; consequently, wasting water or failing to rationalize its use causes environmental damage;
• Water is one of the basic requirements of development, since without water it is impossible to carry out development processes in different economic sectors;
• Competition over water sources between states can sometimes turn this vital commodity into a cause of war, and some countries may use it as a justification for launching wars against their neighbors to seize their water or obtain a sufficient share of the water resources available in the region.

3- Determinants of Water Security

Discussing water security as a right requires the availability of a set of foundations, so to speak, for claiming the right to water security and for reaching a level of benefit and satisfaction from it:

3-1- Political Determinants of Water Security

The political determinant focuses on how to create an enabling environment for the human right to water security. The existence of a political environment that helps meet human water needs constitutes the necessary guarantee for liberating people from coercion. Through the principle of political responsibility and accountability, fair water-production dynamics are created, based on a democratic civic framework founded primarily on transparency and participation, as well as non-discrimination and the rule of equity, enabling individuals to exercise their right to water security.

3-2- Economic Determinants of Water Security

Discussing the existence of an economic determinant of the right to water security necessarily means providing conditions for sustainable growth within the state. Economic growth reduces poverty and provides the infrastructure for water services as well as sanitation facilities through increased income and stable employment opportunities. This requires an economic system based on fiscal and monetary policies for individuals.

3-3- Environmental Determinants of Water Security

The environment is the space in which human beings live and interact with the other living and non-living elements of nature. Water is part of the environment and is one of the variables determining water security, as it ensures human survival and existence because of the relationship of mutual influence between the two.

The environmental strategy supports the right to water security through developing water resources, preserving biodiversity, and achieving a balance between the needs of nature and those of humans without threatening future generations. Adequate protection must be ensured for aquatic communities and groundwater away from depletion. The environment is one of the pillars that preserves the possibility of benefiting from the right to water security, as it is life (Jaffal & Jaoui, 2014/2015, pp. 21–22).

Section Two: Water Policy in Algeria and Its Relationship with Economic Development

Algeria is characterized by limited, irregular, and fragile water resources despite their diversity, while demand is increasing in response to development needs and the necessity of improving the population's standard of living. This may make the water situation an impediment to development if water-resource management is not effectively controlled.

Given the importance of this issue, searching for the most appropriate strategy and ensuring its effective implementation has become necessary to preserve and govern this natural wealth both now and in the future, thereby contributing to achieving and sustaining water security. From this perspective, it is important to examine the state of water security in Algeria and the policies adopted in this field and their implications for food security and agricultural development.

1- The State of Water Security in Algeria

Algeria is characterized by its large area and diverse natural features, which is reflected in the diversity of its water resources, including surface water, groundwater, and rainfall. However, the distribution of these resources is irregular due to the country's geographical location and the variation of its climatic regions between the Mediterranean region, the steppe region, and the Saharan region, which occupies the largest part of its territory. Rainfall is generally low and may be almost nonexistent in some years, contributing to worsening drought and water-scarcity problems.

1-1- Water Sources in Algeria

Water resources in Algeria include natural or traditional water resources represented by rainfall, groundwater, and surface water, and non-natural or non-traditional water resources represented by seawater desalination, wastewater treatment, i.e. recycling of sewage water, and other non-traditional sources.

A- Traditional Water Resources

• Rainwater

Algeria has surface-water and groundwater resources, whose replenishing source is rainfall (Belghali, 2009, p. 74). The country's large geographical area and diverse topography have created several factors affecting rainfall. Nevertheless, 85 percent of this area is located in the Saharan region, where rainfall is almost nonexistent. The northern region, by contrast, has a Mediterranean climate, receiving about 192 billion m³ of rainfall, but most of it flows to the sea and evaporates because of heat. Therefore, rainfall rates decrease in two directions, from north to south and from east to west (Ramadan, 2008, p. 20).

Rainfall in the northern part of the country is concentrated over a period of no more than 100 days, and snow falls on the peaks of the Atlas Mountains. The volume of rainfall is estimated at about 65 billion m³, most of which evaporates (Al-Hajjar, 2009, p. 39).

Rainfall during the autumn and winter seasons is characterized by torrential precipitation, with large quantities falling very heavily within a short period that may not exceed a few minutes. This causes harmful floods affecting agricultural crops, soil erosion, siltation of dams, and limited benefit of the soil from rainfall, most of which flows into the sea because of the steep topography of the northern regions. This makes it necessary to care for afforestation of slopes and inclines, especially the tributaries of dams. For example, the Chlef River experiences sudden fluctuations in its flow rate, ranging from 1 to 2,000 cubic meters per second (Madi, 2006, p. 65).

Table (01): Volume of Rainfall by Region and the Volume of Resulting Flows

Region	Average Annual Rainfall (mm)	Volume of Runoff Resulting from Rainfall (billion m³/year)
Oran – Eastern Chott	318	94.3
Chlef – Zahrez	412	23.8
Algiers – Soummam	442	29.20
Constantine – Seybouse	581	76.17

Source: BENHABIB, KAMIL EDINE. Eau stratégie de développement: situation de l'enjeux, la mutation, N: 32, June 2000. p. 16

• Groundwater

In the north: The technical services of the National Agency for Water Resources (ANRH) and the Directorate of Major Water Infrastructure (DGAIM), within the framework of the National Water Plan, estimated groundwater resources at approximately 1.9 billion m³ annually (National Economic and Social Council, 2000, p. 17). These resources are characterized by ease of mobilization, while some aquifers are subject to excessive exploitation, with their exploitation rate exceeding 90% in 2013.

In 2021, groundwater resources were estimated at approximately 1.7 billion cubic meters, but demand is much higher in the northern part of the country. The important groundwater basins in the Sahara meet 67% of water demand in the south (Fanack Water, 2021).

Table (02): Distribution of Groundwater Resources in Northern Algeria

Region	Water Volume (million m³)
Oran	320
Chlef	190

Algiers	412
Soummam	133
Constantine	163
Annaba	91
Sersou – Zahrez – Hodna	298
Medjerda – Mellegue	47
Nememcha – Aurès	139
Eastern Chott – Saharan Atlas	102
Total	**1,895**

Source: Adel Kedouda, Economics of Water Resources in the Maghreb, Master's thesis, Faculty of Economic and Management Sciences, University of Algiers, 2003, p. 80.

In the south: Groundwater in the south consists mainly of fossil water with a very low capacity for renewal. Water resources are found within two major interconnected aquifer basins, the Terminal Complex and the Continental Intercalary, which form the transboundary aquifer system of the northwestern Sahara. Water is extracted from deep groundwater basins mainly using deep wells, while water is extracted from shallow basins using the traditional foggara system.

Thus, water resources are the result of groundwater generated by floods and seasonal rainfall, which are affected by climatic and environmental changes.

Although surface runoff is almost regularly absent in the Sahara except for Wadi Righ, Wadi M'zab, and Wadi Saoura, the region has significant groundwater resources formed over thousands of years. However, they occur at great depths below the Earth's surface, reaching about 2,000 meters, except in the Adrar region, where groundwater occurs at depths ranging between 200 and 300 meters.

In 2014, Algeria exploited only about 7.1 billion cubic meters annually of this significant water wealth to meet the irrigation and drinking-water needs of the southern population. Thus, a reserve of 3.3 billion cubic meters of exploitable water remained available and could be used to develop Saharan agriculture and reclaim new land. This is currently the most appropriate option because transporting it to the north, according to the relevant departments of the Ministry of Water Resources, would cost the state treasury huge sums, and would only be undertaken as an unavoidable last resort; seawater desalination is preferred (Zoubiri, 2000, pp. 14–15).

• Surface Water

Surface water includes the total water wealth located above the Earth's surface, some of which is retained in dams or water reservoirs and some of which flows in rivers.

Algeria is divided into five major river basins comprising 21 groupings, concentrated mainly in the north, and renewable surface-water resources are estimated at about 22 billion cubic meters. Surface-water flows are low in the Sahara basin, totaling 2.0 billion cubic meters per year. By contrast, the north relies mainly on surface water, with nearly 1 billion cubic meters captured in a number of medium and large dams. Surface runoff occurs as rapid and strong floods that feed the dams during the short rainy season, which usually extends from December to February (Fikri, 2020).

Given its large area, Algeria is also characterized by a scarcity of surface water, which is concentrated mainly in part of the northern slope of the Atlas mountain range.

• Dams

Most countries have begun investing part of the potential of seasonal valleys and permanent rivers by constructing dams and storing some floodwaters that flow during flood periods for use during drought periods in drinking water and agriculture. They are considered successful examples of water-resource development in arid areas, and more should be encouraged because of their effectiveness and ease of distribution. The obstacle to dam construction is the high cost of establishing them.

There are 80 completed dams in Algeria (65 of them in operation) across the national territory, with a total storage capacity estimated at 8 billion m^3. In 2000, Algeria had 44 dams with a storage capacity of about 3 billion m^3, in addition to five other dams under construction, namely the “El Ghedira Dam” in Souk Ahras Province and the “Three Dams” and “Ouzina Dam” in Batna Province. Once completed, the number of dams would become 85, with a total storage capacity reaching 9 billion m^3.

The chief coordinator at the National Dams Agency reported that the rate had reached 44.52%, with provincial rates of 26% in the west of the country, 24% in the center, and 61% in the east.

He also indicated that the 80 dams currently in Algeria suffer from siltation at an estimated rate of 13%, which affects their water-storage capacity and deprives the country of considerable quantities of water annually. He described the process of removing accumulated silt and improving dam storage capacity as complex and costly.

The Inspector General of the Ministry of Water Resources and Water Security stated that dams account for only 33% of water resources produced at the national level, compared with 50% from groundwater and 17% from treatment and purification plants. He explained that the provinces connected to dams during the previous two years were the ones that experienced the greatest water-resource deficits amid scarce rainfall.

• Water Reservoirs (les retenues collinaires)

They are water basins, also called mountain lakes, whose storage capacity does not exceed one million cubic meters. They are mainly used for irrigation and watering livestock and consist of earth embankments with heights ranging from 5 to 15 m. Public authorities did not pay much attention to these water reservoirs because they were considered small and insignificant barriers. This model was observed in the Greater Kabylia region, constructed by the Soviets, or even structures existing from the colonial period (Boukhalfa Dam). In 1979, their number was estimated at 44 barriers with a capacity of 21 million cubic meters. They are located in northern provinces with abundant rainfall (Bouira, Tizi Ouzou, Boumerdes, Constantine). In 1985, 667 barriers were built in various locations over two years with encouragement and assistance from the authorities, and 35 million cubic meters of their 79-million-cubic-meter capacity could be exploited. Construction activity then weakened, and 130 new barriers were established in 1992, with a total capacity of 113 million cubic meters. A sectoral investigation conducted in 1993 concerning the management and exploitation of these dams showed that 80% of the facilities were operational, 75% of their water was used in agriculture, 5% for livestock, and 20% remained unused (Ministry of Water Resources, 2001, p. 32).

The existence of 481 small dams (water reservoirs), filled with 55 million m³ to date, has enabled irrigation of 11,000 hectares. Their capacity was planned to increase to 78 million m³ in 2009 through the construction of 88 dams, which would increase the irrigated area in mountainous regions by approximately 15,700 hectares and improve living conditions for rural households (Hadjres, n.d., p. 6). In Algeria, about 1,365 water reservoirs were also established to exploit rainfall (Ministère des Ressources en eau, n.d.), with plans to accelerate the construction of 627 water barriers and rehabilitate 458 previously constructed barriers, which would be directed directly toward agriculture (Farah, 2009–2010, p. 200).

This type of dam falls within small-scale irrigation works. It did not receive attention in the early 1980s, when the irrigation sector began implementing a wide-ranging program of studies and construction for small agricultural holdings in areas located on the slopes of the mountains in northern Algeria.

• Wells (les forages)

With regard to wells, the Ministry of Environment and Spatial Planning, which was previously responsible for water resources, counted approximately 5,500 wells in 1985. During 1990–1999, more than 2,000 wells were drilled in northern Algeria, providing one billion cubic meters of water, distributed between drinking-water supply at 85.2% (852 million m³) and irrigation at 14.8% (148 million m³). In southern Algeria, 742 wells were completed, providing an annual volume of 221 million m³ for drinking-water supply and 505 million m³ for irrigation (Farah, 2009–2010, p. 200).

In 2004, the National Agency for Water Resources (ANRH) recorded approximately 50,000 wells and boreholes in the northern region alone, enabling the mobilization and exploitation of about 1.9 billion m³ of groundwater annually. By 2013, the number of facilities recorded nationally had reached 139,720 wells and 48,642 boreholes, mainly intended to supply medium and small irrigated areas with water, as shown in the following table:

Table (03): Evolution of the Number of Wells Since the 1980s

Period	Number of wells
1985	5500
1990-1999	7500
2004	50000
2013	139720

Source: Ministry of Environment and Spatial Planning, internal documents, 2015.

B- Non-Traditional Water Resources

In light of demographic growth, declining rainfall, and rising costs of mobilizing and exploiting some traditional water sources, the need arose to diversify water-supply sources through non-traditional water resources, particularly seawater desalination and wastewater treatment and reuse.

• Seawater Desalination

The water-resources sector in Algeria turned to seawater desalination with the assistance of foreign expertise and the conclusion of several international agreements and partnerships, within the framework of cooperation between the energy and water sectors beginning in 2001. Desalination operations relied on several technologies, most notably MSF and MED, which allow the production of electricity and water and require high temperatures reaching 100° for MSF and 60° for MED, in addition to reverse osmosis (Osmose inverse) (National Economic and Social Council, 2000, p. 35).

The Algerian experience in seawater desalination has materialized in a number of projects, including the Hamma and Arzew plants:

• Hamma Plant in Algiers: It was supervised by a team tasked with studying the various modalities, alongside a power station containing two generators with a capacity of 400 megawatts, based on an estimate of US$1,100 per cubic meter of water.

• Arzew Plant: Its production capacity is 40,000 m³ per day, of which 20,000 m³ per day is directed to the population, with the possibility of expanding the plant to reach a production capacity of 80,000 m³ per day. One billion dinars was allocated to the Ministry of Energy and Mines to implement the seawater-desalination project, in addition to a request for authorization for a program amounting to 4 billion Algerian dinars (Dgekoub Saad, 2000, p. 21).

It should be noted that accurately determining the cost of producing desalinated water is difficult because it is affected by a range of technical and economic factors. The main economic factors affecting this cost include (Kedouda, 2003, pp. 70–71):

• Costs of chemicals according to their source, whether local or imported, in addition to transportation costs;
• Fluctuations in foreign-exchange rates against the local currency, and the resulting difficulty in determining costs accurately;
• Inflation rates according to country and time period;
• Financing conditions and interest rates;
• Labor costs.

There are also other seawater-desalination technologies, including distillation, which comprises flash evaporation, multiple-effect evaporation, vapor-compression evaporation, and solar distillation, in addition to membrane desalination technologies.

• Wastewater Treatment (Sewage-Water Recycling)

The use of wastewater in the Arab world remains limited. In addition, the poor condition of networks in cities has kept the notion of impure water influential in this field. Despite the experience of many countries in using treated wastewater, such as Chile, Mexico, and Argentina in Latin America to irrigate agriculture around major cities with wastewater, and China for industrial uses around the capital Beijing, the use of treated wastewater has remained limited in the Arab world (Kedouda, 2003, p. 36).

Algeria's potential from this resource remains very weak, with wastewater discharged into the sea for coastal population centers and into valleys and sebkhas for other settlements. The total volume of wastewater discharged into the natural environment has reached approximately 700 million cubic meters annually, of which only 75 million cubic meters are purified and treated each year, equivalent to approximately 10%, a virtually negligible proportion. The statistics and figures concerning wastewater treatment in Algeria are as follows (Rabah, 2003, p. 28):

• Number of operating treatment plants: 21 plants.
• Number of plants under construction: 23 plants.
• Number of plants undergoing rehabilitation: 19 plants.
• Number of completed plants: 10 plants.

Algeria developed its wastewater-treatment network from 12 plants with a capacity of 90 million m³ per year in 2000 to 100 plants with a capacity of 1.8 billion m³ per year in 2016. According to the Ministry of Water Resources, investments in desalination and the use of treated wastewater will be targeted in the coming years, and cooperation with international companies will be encouraged (Mosbahi, 2019).

1-2- Mobilizing Water Potential in the Service of Algerian Water Security

Table (04): Mobilization of Water Potential in Algeria (billion cubic meters)

Type of Water Resources That Can Be Mobilized	Water Potential	Mobilized Potential	Percentage (%)
Surface Water	5.7	1.8	31
Groundwater	6.5	2.1	32
Total	**12.2**	**3.9**	**32**

Source: Abdelrahman Didouh, previously cited reference, p. 75.

The figures show that the exploitation rate has not reached a high level, as it did not exceed 32%. Therefore, the state devoted major material resources to increasing this rate in response to domestic needs and the requirements of the agricultural and industrial fields (Bouziani, 2000, p. 195).

Table (05): Evolution of Exploitation and Prospects up to 2040

Indicator	1999 (%)	2005 (%)	2009 (%)	2025 (%)	2040 (%)
Drinking Water Supply	78	90	93	98	98
Sanitation	72	81	86	98	98
Daily Water Availability per Capita (liters)	123	155	170	180	180

Source: Abdelrahman Didouh, previously cited reference, p. 75.

Algeria has undergone several transformations and developments in all fields, represented by the restructuring of various economic, administrative, and health activities, reflecting citizens' aspirations to overcome poverty. Given the increasing demand for water—from 123 liters in 1999 and 160 liters in 2007 to 165 liters in 2014—the state resorted to wastewater

purification as a necessary solution. The length of the national sewerage connection network reached 36,000 km, at a rate of 36%, and the table above presents the purification plan for agricultural and industrial use. The quantity of wastewater is estimated at 700 million m³ annually. Accordingly, within a well-defined strategy, the sector was able to achieve the following objectives:

• Daily water supply: 70% for 1,541 municipalities, compared with 45% in 1999.
• Supply once every two days: 18%, compared with 30% in 1999.
• Supply once every three days: 12%, compared with 25% in 1999.

Treatment and purification capacity for wastewater increased from 350 million m³ annually to 600 million m³ annually in 2010. The strategy in this field aims to reach an 82% water-treatment rate by developing wastewater-treatment and purification schemes (Hydro-plus, 2007, p. 5), expanding sewerage networks in all urban and rural areas, rehabilitating 20 plants, and constructing 40 plants.

2- Water Security and Its Relationship with Food Security and Agricultural Development in Algeria

Food security is considered one of the strategic components of agricultural development included in the economic development plan. Accordingly, the following is addressed:

2-1- Relationship between Water Security and Food Security in Algeria

Water security and food security are global issues affecting, or at least one of them affecting, many developing countries. Many of these countries are located in arid or semi-arid climatic regions, causing most of them to suffer from water scarcity and consequently food crises, particularly when rainfall becomes scarce in this part of the world and drought occurs. Developing countries located in regions with rivers, rainfall, and groundwater do not suffer from a water crisis, but nevertheless suffer from a food crisis because they have been unable to develop their natural water sources and transform them into economic water resources ready for immediate use—not because they do not know how, but because of their limited financial capacity needed to do what is necessary. The strategy of achieving food security through self-sufficiency without considering the principles of comparative advantage and optimal allocation of economic resources has led to clear waste of water resources.

Food security and water security are among the country's security priorities, but they cannot be separated. When discussing food security or water security, we are discussing a complete ecological system that requires study and analysis to determine the best ways to manage what is available in the best possible manner.

Food self-sufficiency requires an economy capable of producing sufficient exports to cover food imports and meet the food needs of its population. It also requires some parts of the world to have moist soils resulting from rainfall and irrigation in order to grow enough food for the world's population. In the context of food self-sufficiency, water security can be achieved through a social and economic policy for optimal use of water resources to meet needs. Reliance on trade for food-security purposes involves some risks, such as deteriorating terms of trade in world markets, lack of confidence in suppliers, price instability, and the possibility of bans on food trade. Food security and water security in countries facing water-related complications are closely linked to the strength of the trade position, which is reinforced by regional stability and comprehensive security (Bougrara & Abbassi, 2020, p. 17).

2-1-1- Water Security and Food Security in Algeria

Water security and food security are among Algeria's security priorities and cannot be separated; they are two sides of the same coin. To determine how these two terms are viewed in Algeria and whether these two forms of security have been achieved, each concept will be addressed separately.

• Water Security in Algeria

Water resources in Algeria have a strategic character in the country's comprehensive development because of their close connection with sustainable development. Water in Algeria is a scarce and precious resource whose use must be rationalized to meet the needs of the population and the national economy without compromising the needs of future generations. Algeria is classified among the world's poorest countries in terms of water potential, falling below the theoretical minimum threshold of scarcity set by the World Bank at 1,000 m³ per person per year. The theoretical water endowment in Algeria, which was estimated at 1,500 m³ per person per year in 1962, declined in 1999 to 50 m³ per person per year. The water problem in Algeria is intensified by climatic characteristics ranging from arid to semi-arid over most of Algerian territory, and rainfall is consequently insufficient, threatening a decline in resources at a time when demand for this resource is increasing because of demographic growth and the expansion of consuming sectors such as industry, agriculture, and tourism.

Given its large area, Algeria is also characterized by a scarcity of surface water, which is concentrated mainly in part of the northern slope of the Atlas mountain range. Algeria's water potential is estimated at less than 20 billion m³, only 75% of which is renewable; non-renewable water resources include aquifers in northern Sahara.

The number of surface watercourses in Algeria is estimated at about 30, most of them in the Tell region. They flow into the Mediterranean Sea, have irregular water levels, and their capacity is estimated at 12.4 billion m³.

Despite the sensitivity of the water problem in Algeria, successive governments since independence have not given this vital sector the necessary importance in national development programs. In particular, insufficient attention was given to dam construction, which constitutes the principal infrastructure for water storage, increasing the accumulation of problems, causing harmful delays to the national economy, and creating numerous difficulties for the population. Experts estimate the

number of theoretically suitable sites for dam construction in Algeria at about 250. However, the number of small and medium dams, including 50 large dams with storage capacities exceeding 10 million m³, has resulted in a total storage volume of 4.908 billion m³. Yet the average volume of stock available in previous years was estimated at only about 1.75 billion m³, equivalent to 40% of the theoretical total filling capacity, because of climatic conditions (drought) and dam-siltation problems. In 2016, work was also undertaken under a program to construct 22 new dams with a theoretical total capacity of 7 billion m³, while studies were being conducted to prepare projects for constructing another 52 dams in the future.

The Algerian government considers water to have an economic dimension, but it also considers the social dimension of water to outweigh the economic dimension. This led the Algerian government not to apply the real price of water. There is a system for water distribution and a system for pricing, with several tariff tiers. As for the ordinary citizen, they benefit from an almost symbolic price and in fact pay only one-third of the price per cubic meter of water because its value to the Algerian Water Company ranges between 32 and 38 Algerian dinars. The ordinary citizen pays only 11 Algerian dinars per cubic meter. There is financing from the state budget, as is also applied to electricity. The same applies to sanitation water services. However, the problem of waste remains because of the low price of water. Therefore, five tariff tiers were established for industrial users and administrations, with higher prices applied to them. Awareness campaigns concerning water are also conducted in schools and on television, but this is not sufficient.

Algeria has overcome the problem of water scarcity and is in the process of achieving water security by reaching a share of 170 liters per person by the end of the current year and continuing to strengthen storage capacity by increasing the number of dams to 82 in 2014. The Beni Haroun Dam represents the second most important water complex in Africa after the Aswan High Dam in Egypt. It seeks to meet the drinking-water needs of about 5 million people in the future in the provinces of Mila, Constantine, Jijel, Oum El Bouaghi, Khenchela, and Batna, in addition to irrigating agricultural areas covering more than 30,000 hectares.

• Food Security in Algeria

The agricultural sector in Algeria has gone through several stages since independence because of the importance of the capital it represented. It was one of the fundamental constants for improving national food security through the development of agricultural production. The process began with self-management in 1963 and the Agrarian Revolution in 1971. With stability and the gradual recovery of the country's financial resources at the beginning of the 2000s came the third stage, in which measures were implemented to support the reconciliation policy and revitalize rural development. In 2009, the fourth stage began, represented by the Agricultural and Rural Renewal Policy, in which an integrated, participatory, decentralized development approach was generalized and a genuine partnership between the public and private sectors was gradually built.

Following the sudden and collective departure of the colonists after independence, the state focused its attention on the richest agricultural holdings for self-management and collective management by farmers. The Agrarian Revolution then confirmed the socialist orientation characterizing the agricultural economy during 1971–1979. This involved nationalizing the largest private properties owned by nationals and unused lands, adopting collective management, and establishing numerous bodies for agricultural research, information, extension, and the development of infrastructure and basic facilities in rural areas. Financing remained public in the form of subsidies dependent on oil revenues. There was considerable optimism about building this economy, but its chances of success gradually faded because of demographic growth and increasing demand.

As the state gradually restored security in the late 1990s, public finances recovered, and the structural adjustment program was closed, an ambitious recovery program was launched for the period 2000–2008, known as the National Agricultural Development Plan.

At this stage, support for agricultural holdings began and was expanded to the rural sphere. A Minister Delegate for Rural Development was subsequently appointed and a sustainable strategy was established for its implementation. Agricultural and rural policies were then coordinated, imports of agricultural equipment were increased, and administrative technical bodies intensified their efforts in supervision, guidance, and extension services and adapted them to producers' new demands, with the aim of raising production and productivity levels and increasing agriculture's contribution to food security. Efforts to develop agriculture contributed to food provision and stimulated growth, with the value of agricultural production exceeding US$29 billion in 2012, according to the ministry's Director of Agricultural Statistics. According to the Algerian Minister of Water Resources, the country would invest US$15 billion in the water sector between 2010 and 2014. He added that 19 new dams would be built by 2014. Emphasis was also placed on the rural renewal policy, which is primarily based on strengthening national food security. This policy rests on three pillars:

• Rural renewal through balanced and harmonious development among rural regions.

• Agricultural renewal through encouraging the intensification and modernization of production on agricultural holdings.

• Adoption of a program to strengthen human capacities and technical support, which would modernize agricultural management methods and increase investment in agricultural research, training, and extension; encourage the introduction of new technologies and their rapid transfer into the production environment; strengthen the material and human capacities of all institutions and bodies responsible for supporting sector producers and operators; and strengthen inspection, veterinary protection, plant-health services, seed and seedling certification services, technical inspection, and forest-fire prevention.

The implementation of the Agricultural and Rural Renewal Policy in its first phase, within the framework of the 2010–2014 five-year plan, mobilized approximately €10 billion to modernize administration and various mechanisms for supporting prices at the consumption level.

Despite Algeria's efforts to develop the agricultural sector, including allocating US$1.7 billion to support agricultural investment, this did not prevent it from becoming, since 2015, one of the world's six largest wheat importers, with a quantity exceeding five million tons annually. Accordingly, the study concluded that achieving food security depends on three basic factors relating to climate, the human factor, and government policies.

The Algerian government also adopted measures to rationalize water exploitation within the framework of the development strategy for the water resources and environment sector, with a 2030 outlook. The strategic axes of the 2015–2019 five-year plan were as follows:

• Mobilizing water resources by constructing 26 dams with a storage capacity of 985 million cubic meters.

• Providing drinking water by constructing 2,440 kilometers of pipelines annually and rehabilitating 1,680 kilometers of drinking-water pipelines.

• Expanding the sewerage network and treating wastewater, and constructing 60 treatment plants and 6,000 sewerage collectors.

• It was expected that 32 irrigation projects and 219 small dams would be completed.

2-2- Effects of Water Policy on Food Security in Algeria

Until 1996, the number of dams existing throughout the national territory was 20 dams: 20 dams in the western region of the country, 12 in the western region and 8 in the eastern regions, distributed in a manner corresponding to the presence of French colonists before independence, who had selected the Mitidja plains, the Oran plains, and the Annaba plains. Among the eight dams, two—Iraguene Dam near Jijel and Ighil Emda Dam near Bejaia—were dedicated to generating electricity. At that time, the capacity of all dams was estimated at 500 million cubic meters compared with a storage capacity of about 1,794.6 m^3, and each year they could store less than 8% of total annual rainfall, estimated at 65 billion cubic meters. As for the remaining water collected in valleys, estimated at 15 billion m^3, it flowed into the sea or disappeared into the desert sands. This excludes other water quantities, amounting to 50 billion m^3, that infiltrated underground or evaporated into the air.

During that period, the decline in labor productivity in the agricultural sector was mainly due to the means of production used and reliance on traditional irrigation methods (rain-fed agriculture), which deepened the impoverishment of the population. Algerian farmers at that stage had limited means and did not own the land, and social circumstances often forced many farmers to rent out their lands as a result of the fragmentation and destruction suffered by the Algerian family under colonialism, which pursued a scorched-earth policy involving the seizure and confiscation of Algerian land at any cost.

Therefore, it was natural to reconsider the agricultural strategy to ensure food security immediately after independence.

The numerous problems experienced by the agricultural sector across its various stages, related to production, financing and supply, marketing, or the sector's structural relationships within the country's economic structure internally and externally, led to the adoption of the Agrarian Revolution in the hope of eliminating the backwardness into which the sector had fallen and abolishing the khammassa system.

The various agricultural policies adopted since independence, as a constant feature of national policy, had fundamental objectives aimed at improving national food security through developing production and contributing to improved living conditions. Thus came, after the 1963 self-management phase, the 1971 Agrarian Revolution, whose objective was social justice and the elimination of the khammasa system. It was followed from 1980 by a phase characterized by decline as a result of the global economic crisis. In the current phase, beginning in February 2009 and based on the President's speech in Biskra, a strategic plan for the sector was adopted, aiming at an integrated, participatory, and decentralized development approach within a new form of good governance and management, represented by directing the state to make profound changes in the relationships among actors in the agricultural world and involving both the public and private sectors in development.

Total food production (national production – imports) increased eightfold between 1962 and 2012. Agricultural production accounted for 70% of food availability, with an average growth rate of about 3% per year in 1981–1990, 3.2% between 1991–2000, and 7.03% between 2001–2011, and 70% at the end of 2021.

As for agricultural land, more than 90% is in the hands of the private sector, representing either private ownership or land opened by the state in the form of a concession renewable every 40 years. The state's role is limited to regulation, supervision, and various forms of support. Through our study of the agricultural reality and its development during this decade, it became clear that the strategy followed in this sector is based on the following pillars:

• Permanent strengthening of national food security and transforming agriculture into a genuine engine of economic growth. This strategy also consists of reducing weaknesses and developing strengths through the involvement of different private and public actors and the requirement of sound governance in management;

• Preparing legislative and regulatory frameworks more suited to the requirements of modernity;

• Developing and improving agro-industry;

• Mobilizing and sustainably valorizing water resources;

• Marketing that ensures better valorization of production;

• An institutional framework for supervision, research, and development;
• Necessary strengthening of the control function.

2-2-1- The Three Pillars of the Agricultural Strategy for Ensuring Food Security

• Rural Area Development Strategy

This strategy aims at harmonious and sustainable development of rural territories and emphasizes decentralization and participatory rural development within the framework of state reform, democratization of society, and good governance of territories. The rural renewal program, which is broader than agricultural renewal, addresses the problems of families living and working in rural areas, especially in difficult regions where life and production are difficult (mountains, steppes, and Sahara), through watershed protection operations, forest-resource management and protection, combating desertification, managing protected areas, and land reclamation.

• Agricultural Renewal Strategy

This approach aims to intensify and modernize production on agricultural holdings. It means integrating public- and private-sector actors for sustained and significant internal growth in agricultural production. Among the priorities identified are cereals, dry legumes, red and white meat, potatoes, industrial tomatoes, olive and date-palm cultivation, seeds, seedlings, and genetic resources, as these priorities are considered essential to individual livelihoods and to eliminating dependency.

• Human Strategy

Strengthening human capacities and technical assistance includes the following areas: modernizing agricultural management methods; investing in agricultural research, training, and extension; strengthening the material and human capacities of all institutions and bodies responsible for supporting sector producers and operators; strengthening inspection, veterinary protection, plant health, seed and seedling certification services, technical inspection, and forest-fire prevention.

Food security has become a concern for all states, as the food-security problem has acquired an increasingly political character in international relations, particularly with regard to wheat (United Nations University Report, n.d., p. 81). Through the following tables, we will attempt to clarify the efforts made by Algeria to ensure its food security, which is essentially based on its water security. Thus, food is not only a guarantee of life but also the preservation of health in its best possible condition (Aubin, 1974).

Conclusion:

The study shows that water security represents one of the fundamental pillars for supporting food security and agricultural development in Algeria, given the direct link between water availability and the sustainability of agricultural activity and its ability to respond to growing food needs. The study has shown that Algeria's water problem is not related only to the limited availability of natural resources, but also to how they are mobilized, allocated, managed, and used efficiently.

Despite the efforts and investments undertaken by Algeria in dams, seawater desalination, groundwater exploitation, wastewater treatment, and the development of distribution networks, achieving sustainable water security remains a challenge in light of the arid and semi-arid nature of the climate, irregular rainfall, demographic growth, and increasing water demand for various uses.

The study concludes that strengthening food security and agricultural development does not depend solely on increasing available water resources; it requires adopting integrated and sustainable management of water resources, increasing water productivity in the agricultural sector, developing non-traditional water sources, rationalizing consumption, and improving coordination between water and agricultural policies. Therefore, Algeria's success in supporting its food security is largely linked to its ability to transform the water resources it mobilizes into more efficient and sustainable uses, while taking future climatic and demographic pressures into account.

The analysis produced a set of key findings. It showed that Algeria has indeed adopted a range of policies and measures to address deficiencies related to water demand through dam construction, extending drinking-water pipelines, developing seawater desalination, and maintaining networks and equipment. The study also confirms the importance of sound and integrated water-resource management in strengthening water security and linking it to the requirements of the agricultural sector and food security. Conversely, Algeria's geographical location and arid and semi-arid climate, together with demographic growth and expansion of agricultural and industrial uses, remain factors increasing pressure on water resources, making the current and future water situation a direct challenge to the sustainability of food security and agricultural development.

Recommendations:

• Strengthen awareness programs on rationalizing water consumption and conserving water, and involve citizens and economic actors in efforts to achieve water security.
• Expand the reuse of treated wastewater in suitable activities, particularly agricultural uses, while providing the technologies and controls necessary to protect the environment and health.
• Increase water-use efficiency in the agricultural sector and develop water-saving irrigation methods to support sustainable agricultural production under conditions of water scarcity.
• Support applied studies and research related to water-resource management, develop non-traditional water sources, and improve coordination between water and agricultural policies.

• Strengthen legal and institutional frameworks and monitoring and maintenance mechanisms to ensure the protection, proper mobilization and allocation, and sustainable exploitation of water resources.

References:

Al-Bassa, Mazen, & Dawoud, Hossam Al-Din. (2021). The Water Crisis and Its Impact on Arab National Security. Ninth International Scientific Conference on the Arab Economic Situation and Future Options, Zarqa, Jordan.
Ben Ghaida, Sara, & Harkat, Said. (2020). Employing Modern Technology to Achieve Water-Resource Security: A Review of Global Experiences. Journal of Money and Business Economics, No. 02.
Boukhaari, Fatima, & Ziar, Issa. (2020). Virtual Water as a Contributing Factor to Achieving Water and Food Security in the Middle East and North Africa. Madarat Journal of Social and Human Sciences, No. 01.
Bougrara, Saleh, & Abbassi, Siham. (2020). Investment in Water Resources: A Means of Achieving Water Security. Journal of Scientific Research in Environmental Legislation, No. 01.
Belghali, Mohamed. (2009). Water-Resource Management Policy in Algeria: Diagnosis of the Reality and Prospects for Development. Journal of the Academy for Social and Human Studies, Issue Two.
United Nations University Report. (n.d.). Food Security Strategy in the Arab States. Center for Arab Unity Studies, Beirut.
Jaffal, Rabah, & Jaoui, Elias. (2014/2015). The Impact of Water on Egyptian National Security [University thesis]. Mouloud Mammeri University, Tizi Ouzou.
Al-Habiteri, Nabila. (2017). Water-Resource Security in Algeria: Reality and Future. Journal of Research and Development Studies, No. 01.
Al-Hajjar, Ziad Khalil. (2009). Arab Water and Food Security (1st ed.). Dar Al-Nahda Al-Arabiya.
Zoubiri, Rabah. (2000). The Problem of Drinking Water in Algeria between Natural Scarcity and Poor Management. Economic Journal, No. 07.
Salhi, Nassira. (2016). Water Security in the Context of Comparative Water Governance. Algerian Journal of Security and Development, No. 09.
Farah, Rachid. (2009–2010). Water-Resource Management Policy in Algeria and the Extent of Privatization in the Water Sector in Urban Areas [Doctoral dissertation]. University of Algiers.
Fikri, Mohamed. (2020, January 23). The Main Sources of Water in Algeria. Mazid Website.
Ramadan, Kifah Abbas. (2008). The Water Crisis in the Maghreb Countries. Center for Regional Studies.
Kedouda, Adel. (2003). Economics of Water Resources in the Maghreb [Unpublished Master's thesis]. Faculty of Economic and Management Sciences, University of Algiers.
Madi, Mohamed. (2006). The Problem of Water-Resource Development in Algeria, with a Case Study of Resorting to Non-Traditional Sources [Master's thesis]. University of Algiers.
National Economic and Social Council. (2000). Draft Preliminary Report on Water in Algeria: One of the Greatest Challenges of the Future.
Ministry of Water Resources. (2001, December 30). The Water Problem: Emergency Program [Presentation before the Council of Ministers].
Hadjres, Mansour. (n.d.). Water Resources in Algeria: Potential, Achievements, and Future Challenges from a Sustainable Management Perspective. Abderrahmane Mira University, Bejaia.
Hydro-plus. (2007). Journal of Professionals in the Field of Water and Sanitation, Year 18.
Aubin, M. (1974). Pratique de l'alimentation en collectivité (3e éd.). ESF.
Bouchentouf, S., & Benabdeli, K. (2021). Water resources and food security in Algeria: Diagnosis and new strategy proposition. African Journal of Agricultural Research, 17(3), 414–424. https://doi.org/10.5897/AJAR2020.15125
Bouziani, M. (2000). L'eau de la pénurie aux maladies. Ibn Khaldoun.
Dgekoub Saad. (2000). Urgence signalée umutaton. N°32.
Fanack Water. (2021). Water Resources in Algeria.
Food and Agriculture Organization of the United Nations (FAO). (n.d.). WaPOR activities in Algeria: Remote sensing for water productivity.
Ministère des Ressources en eau. (s. d.). Gestion dynamique des Barra.
Mosbahi, Z. (2019). Algeria Country Commercial Guide: Public Works, Infrastructure Development, and Water Resources.
Rabah, M. (2003). Un programme d'investissement ambitieux. Import Maire, N°36.
UN-Water. (2013). Water security and the global water agenda: A UN-Water analytical brief. United Nations University, Institute for Water, Environment and Health (UNU-INWEH).