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Climate change and scarcity of water resources in Algeria

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Abstract

The importance of work is due to the importance of water in the continuation of human life and its great role in practicing its various activities, which concern industry, agriculture and various fields.

The research methods included the increasing scarcity of water resources resulting from the decrease in the quantities available to the individual, the deterioration of the quantity and the objectives of economic and social development, thus imposing the development and definition of a water management strategy in the medium and long term. In recent years, the water scarcity crisis has increased and exacerbated due to the drought wave that the region suffers from, and it has greatly affected the region.

As a result of the research, by the year 2025, a deficit of one billion cubic meters of water will be recorded. It is also possible to avoid this deficit in the hydrographic region of Constantine – Seybousse – and this is due to the dams that are in the process of being completed.

In order to eliminate the shortage of water in the region, the amount of storage in dams must be increased and water desalination plants should be established in several areas in order to re-use wastewater. We can also avoid the shortage in the amount of water by building small dams and hill reservoirs, and this is to avoid siltation in large dams. Among the solutions are also increasing surface and groundwater resources, searching for new resources, dealing with losses, and improving the quality of available water.

***Keywords*:** Water, Dams, Water resource, climate, groundwater, evapotranspiration, desalination.

Introduction

Algeria is a southern Mediterranean country with a semi-arid climate (300–400 mm total annual rainfall) (Onm, 2010). It is one of the poorest countries in terms of hydroelectricity, with a large gap between east and west. This general weakness of precipitation is linked to internal spatial imbalances. The western regions of Algeria suffer from drought, while the eastern part of the country is characterized by a humid climate due to its mountainous terrain. There are wadis whose contribution exceeds 1,000.106 m^3/year (Remini, 2010).

Water resource problems at the national level therefore remain a major concern due to these unfavorable climatic conditions, rapid population growth and the quantitative and qualitative degradation of surface and groundwater**.**

Algeria is among the poorest countries in terms of water potential, i.e. below the theoretical scarcity threshold set by the World Bank at 1,000 m^3 per inhabitant per year (CNES, 2000) [1].

The water situation in Algeria is a burning topical issue, particularly in terms of drinking water supply. This question is fundamental in more ways than one. It is first of all because of its decisive impact on the living conditions of citizens. It is also important because of its certain influence on the proper functioning of the national economy and on the balance of our environmental system. Finally, it is so in that it constitutes today and throughout the world, a leading geostrategic issue (ADE 2002).

Due to its geographical location in the arid and semi-arid zone, Algeria is subject to unfavorable physical and hydro-climatic conditions. Indeed, since 1975, a gradual decrease in rainfall has occurred in the Quest region before spreading to the whole country. The rainfall deficit compared to the average is around 30% [2].

The observed climate changes and the drought that has been going on for several decades in North Africa have particularly affected Algeria and have had a negative impact on the country's water resources.

Climate, morphology and rainfall in Algeria. From North to South of the Algerian territory, there are three sets which differ in their relief and morphology: the Tell chain and the coast, the Atlas chain which runs along the High Plains further to the South, and the Saharan desert which is extends beyond the Atlas Mountains. This arrangement of the relief, marked by different climatic conditions, determines the agriculture of the regions and the volume of water resources.

Most of the Algerian territory is a desert (87%) where rainfall is almost zero, but which contains significant fossil

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Table 1. The type of climate in each region and the percentage it represents of the national area
Таблица 1. Тип климата в каждом регионе и его процентная доля от территории страны

Region	Share of national area, %	Type of climate
Tellian region (North)	4	Mediterranean on the coast
Highland steppe region (between the Tellian Atlas and the Saharan Atlas)	9	Semi-arid
Region saharienne (Sud)	87	Arid

groundwater resources. The northern part, characterized by its Mediterranean climate, has renewable water resources, both for surface water and groundwater.

90% of surface waters are located in the Tell region, which covers about 4% of the territory.

The country is characterized by a strong disparity between East and West.

The western region is well endowed with plains but benefits from low rainfall. The eastern region is a mountainous area where the main rivers of the country flow.

The climate of Algeria is known for its geographical diversity and its great interannual rainfall variability. Two elements are to be distinguished: variability in terms of rainfall between the West (350 mm of rain on average), the East (1,000 mm) and the high reliefs (where some years can reach 2,000 mm), which becomes almost non-existent from the Sahara (average less than 100 mm) and a concentration of precipitation over time (from December to April each year, when the climatic demand, evapotranspiration, is the lowest) [3].

The main hydraulic problems in Algeria. The growing scarcity of water resources resulting from the reduction in the quantities available per inhabitant, the degradation of the quantity and the objectives of economic and social development therefore impose the development and definition of a water management strategy in medium and long term. The water problem is aggravated in recent years of drought that have affected the entire territory, have shown how necessary it is to pay the greatest attention to water. This vital resource is threatened in its quality and in its quantity. Despite the construction of new dams and the use of desalination, Algeria will record a water deficit of 1 billion m^3 by the year 2025.

Siltation of water dams in Algeria. The number of dams used in Algeria is 65 out of the 80 completed dams with a capacity of 8 billion m^3.

Receive more than 40 million m3 of solid material annually. The distribution of the dams on the five hydrographic basins clearly indicates that the dams of the region of Chéliff-Zahrez are the dams most threatened by the phenomenon of siltation, since the annual sedimentation rate is 0.75%. This is due to the strong erosion of the watersheds of the region, favored by the nature of the soils and the absence of afforestation. Even for small dams, the filling rate assessed in 2002 in the Chéliff-Zahrez watershed is 16% of the total capacity, it is much higher compared to that of other regions.

Water availability in Northern Algeria. Surface water is stored in dams. In 2022, Algeria has 65 large dams with a capacity of 8 billion m^3.

The water problem has been aggravated in recent years by a drought that has affected the entire territory of our country, and which has shown how necessary it is to pay the greatest attention to water. The division of Northern Algeria into four regions is based on the following criteria:

– the geographical and natural characteristics of the regions;

– the grouping of watersheds and sub-watersheds, between which transfer needs exist.

We note that the global confrontation by 2020 has made it possible to quantify a deficit of approximately 0.9 billion m^3 in northern Algeria. The only region that seems to escape the deficit at this horizon, is the hydrographic region of Constantinois–Seybouse–Mellègue, knowing that it was in deficit at the horizon of 2000 and was able to absorb this deficit thanks to the high regularizable volume ensured by the dams in construction. For example, the Beni Haroun dam, which regulates a volume of 432 million m^3.

We note that currently, the regions of Algiers Soummam–Hodna and Oranie Chott Chergui are in deficit, which has led to a reduction in water intended for irrigation in order to favor the supply of drinking water (AEP) in these regions. This accentuated deficit in the regions of Chéliff-Zahrez and Algiers Hodna–Soummam by 2020. The confrontation between resources and needs is a revealing and very significant indicator that guides us as to the future of the water policy that we are conducting in order to mitigate the effect of the deficit. It is clear that northern Algeria registers on the one hand, an enormous lack of resources at the very moment when the needs increase and on the other hand, the volume of water that can be mobilized is decreasing. This is due to the various natural or human problems that affect the sites likely to capture water [4].

Conventional waters

Surface waters. The volume of water on Earth in solid form,liquid and gas is estimated at 1,384,120,000 km^3 of which only 0.26% is directly usable fresh water. It is estimated that there is theoretically enough fresh water to feed some 20 billion people. Unfortunately it is not evenly distributed, as evidenced by the vast arid and semi-arid regions.

Algeria is a semi-arid country, even Arid (200 to 400 mm) and the water resources are weak, irregular, and located in the coastal strip, the total contribution of precipitation would be of the order of 100 billion m of water per year of which 12.4 billion m^3 in superficial flows, and only 6 billion m^3 can be mobilized taking into account technically favorable sites (Hydrology, topography, geology) [6].

Properties of sea water. The presence of salts in water strongly modifies certain properties (density, compressibility, freezing point, activity coefficient) while others are less influenced (viscosity, light absorption). Other properties essentially depend on the amount of salt in the water (conductivity, osmotic pressure).

The temperature of sea water can vary from –1.9 °C under the influence of polar currents (freezing point of sea water at a concentration of 35 g/l of salts) up to 35 °C at the level of the Arabian Peninsula.

The different properties of seawater depend on its temperature, salinity and pressure (related to depth). They can be highly variable from place to place due to large variations in salinity, temperature and depth [7].

Desalination of sea water. Water desalination is a process that makes it possible to obtain fresh water from brackish

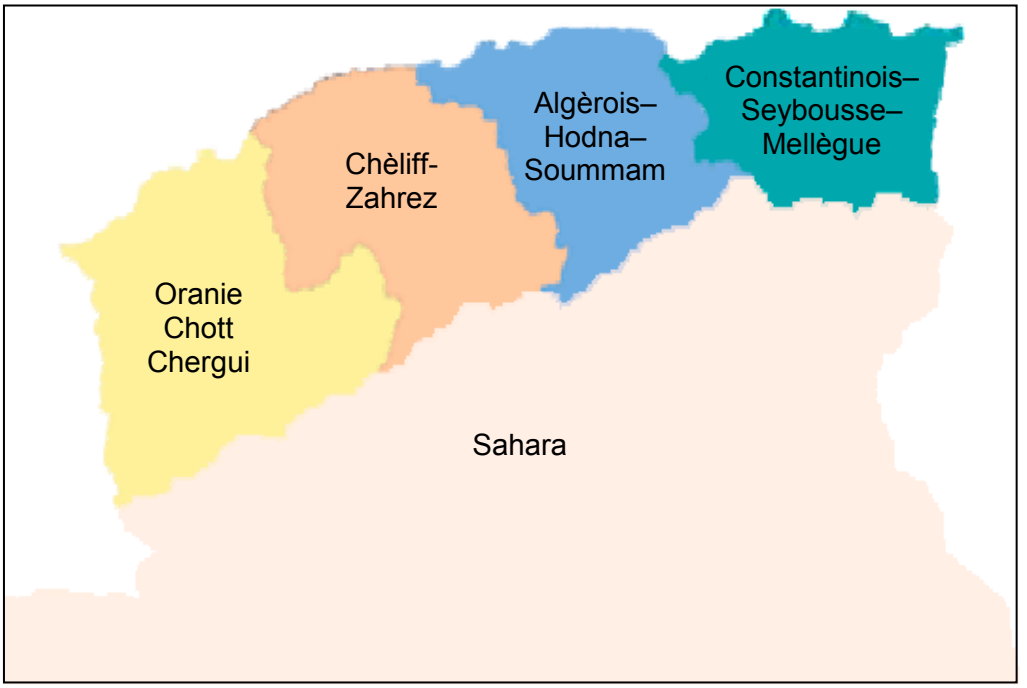

Figure 1. Division of northern Algeria into regions [5]
Рисунок 1. Деление северного Алжира на регионы [5]

or salt water. Brackish water is undrinkable salt water with a lower salinity than seawater. Brackish water contains between 1 and 10 g of salts per litre.

It is sometimes surface water but most often groundwater which has become loaded with salts while crossing the soil. Their compositions therefore depend on the nature of the soils crossed [8].

The study and construction of a reverse osmosis desalination unit with a capacity of 200 m^3/d.

The study and construction of a seawater desalination unit using the multi-flash technique, with a daily capacity of 480 m^3.

Following the drought of recent years which caused a lack of drinking water in the majority of municipalities, an emergency program was developed by the government to compensate for the lack of water resources. The aim is to build 21 desalination stations with a production of 57,500 m^3/d.

The desalination of sea water remains a safe solution, given the drought that has plagued our country in recent years. However, it would be preferable for the desalination units intended to supply drinking water to the population to operate only during periods of crisis and long drought.

Strategies to increase water storage. To avoid catastrophic water scarcity by 2025, we must maximize surface and groundwater resources, search for new resources, address losses, and improve the quality of available water. Water quality is a major issue because it has been threatened by human activities for 30 years. Innovative water resources planning is needed to improve local needs in three main categories (industrial, agricultural and private). In Algeria, it is clear that on the one hand there is a significant shortage of resources, but on the other hand the need is increasing and the quantity of water that can be mobilized is decreasing for various reasons. A natural or human problem that affects a place that can absorb water. Based on this observation, we propose a set of proposals aimed at protecting the resources currently mobilized, but trying to increase them as much as possible. This leads to reduced deficits and increased satisfaction. Improve current and future conditions to achieve a state of equilibrium. Our suggestions are:

Use of artificial groundwater recharge. Some hydraulic problems can be solved by artificial recharge of the aquifer. Dangerous drawdowns due to overexploitation of water in the Mitidja aquifer have even caused road subsidence in the region. Vigorous pumping of the aquifer caused seawater intrusion into the coastal aquifer of the Oued Nador plain. The salt wedges continue to spill over the water table. It is time to popularize this mode of water storage in Algeria, especially since it does not require sufficient material resources. However, first of all, it is necessary to carry out a survey of underground aquifers that can store water and determine where such hydraulic works will be carried out. When building a dam, it would be desirable to combine it with an artificial rise in the water table. The artificial recharge of aquifers could be an alternative solution to the billions of cubic meters of water that still flow into the ocean and cannot be mobilized by the construction of dams. It can also mitigate the subsidence of groundwater tables caused by insufficient mobilization of surface resources.

Dam dredging. Dredging is as expensive as building a new dam, but dredging technology is essential when dam stability is threatened or when land for new construction is scarce. After having accelerated the silting up of the Fergoug III dam (today), Algeria acquired in 1989 a new rotor suction dredger called "REZOUG Youcef". The 300 ton gross weight dredge is designed to pump 2.5 tons to a height of 28 meters., a 700 mm pipe with a maximum mixed flow of 1600 l/s and a dredging depth of 3 to 16 m, the results obtained during this dredging are presented below.

Results of the work of the dredge "REZOUG Youcef"
Результаты работы земснаряда «REZOUG Youcef»

Initial capacity of the dam ..... $18 \cdot 10^6$ m³
Capacity before desilting ..... $3{,}9 \cdot 10^6$ m³
Vase volume ..... $14{,}1 \cdot 10^6$ m³
Devasted volume (density 1.6)..... $6{,}5 \cdot 10^6$ m³
Maximum silting depth ..... $16 \cdot 10^6$ m³
Amount of water used ..... $7 \cdot 10^6$ m³

Construction of small dams and hill reservoirs. Because there is no suitable place to build a large dam, it is encouraged to build reservoirs in the mountains. These are small, shallow dams built with earth embankments that allow local management of this method of storage. Algeria currently has more than 61 small dams distributed in 04 river basins in northern Algeria, as shown in table 2.

Algeria took part in the early 1980 in an ambitious program to build a large number of mountain reservoirs. Unfortunately, this experiment was a semi-failure. Some reservoirs were silted up during the first years of operation, while others were washed away by the first floods. Algeria now plans to build more than 500 mountain reservoirs over the next five years to protect water and soil and minimize sediment intrusion into large dams. These small economic structures can mobilize millions of m³ of surface water for irrigation. However, carrying out such work requires very extensive and serious technical research to avoid two main problems: rapid siltation of reservoirs by one or two floods; failure of the levee during flooding due to ignoring the levee saturation line.

Wastewater recycling and reuse. Currently, the treated wastewater from the existing treatment plant is discharged into the wadi, but in areas where the water demand is not met. Therefore, it does not make sense to continue discharging treated water into the wadi. Currently, the sewage plant park consists of 77 stations (35 municipal areas, 34 industrial areas and 8 tourist areas). Installed capacity was estimated at nearly 140 million m³/year at the end of 1987. Most wastewater treatment plants are now closed for various reasons, including maintenance. Given Algeria's critical situation in terms of water resources, we need to find quick solutions for these stations. Because not so long ago, the unconventional water resources of Algeria. Falling into alternative solutions to increasingly scarce traditional resources. In terms of emissions in the urban environment, the volume of wastewater discharged by the sewerage network, which represents approximately 75% of flows consumed, was 350 million m³ in 1979 and 660 million m³ in 1985. Estimate. 1.3 billion m³ in 2020.The four regions in 2020 are distributed as follows.

Conclusions

In Algeria, a deficit of 1 billion m³ will be recorded in 2025 (in the case of poor water management and lack of control of unconventional resources). The only region that seems to escape the deficit at this horizon is the hydrographic region of Constantinois–Seybousse–Mellègue thanks to the high volume that can be regulated by the dams under construction, in particular that of Beni Haroun, which allows an annual volume of 430 million m³ to be regulated.

Water storage has always been at the forefront of the concerns of states in the Maghreb region. Today, the storage of 44 surface and underground waters represents 30 billion m³ (without taking into account the fossil waters of the deep aquifers) distributed as follows: 19 billion m³ in Morocco, 9 billion m³ in Algeria and approximately 3 billion m³ in Tunisia.

To overcome the predicted water shortage in the region by 2025, we need to increase storage capacity, minimize losses and explore other more profitable reservoirs. The lack of favorable sites and the excessive cost of the project make the construction of a large dam less likely. The Maghreb is a semi-arid and arid region with excessive evaporation rates in some places 2 meters/year. For example, Morocco has an evaporation loss of 1 billion m³/year out of 14 billion m³.

Algeria loses about 200 million m³/year out of the 5 billion m³ stored in dams. Water erosion is severe in the Maghreb region. It is estimated that dams in the three countries record more than 130 million m³ of silt each year. Another growing problem in the region is the eutrophication of lakes and dams. For these reasons, it is time to avoid large structures in favor of small and medium reservoirs and aquifers. 500 mountain reservoir construction projects implemented in Algeria Introduced from 2000. Artificial recharge of aquifers is the best way to store water, avoid major losses through evaporation and siltation, and improve quality some water. Unfortunately, the technology is still in its infancy in the Maghreb region, especially in Algeria. It's time to explore new underground reservoirs (aquifers) and expand the experience to the whole region. It is also desirable to combine both options. Construction of small and medium capacity dams and aquifers. Experiments carried

Table 2. Distribution of small dams in northern Algeria
Таблица 2. Распространение малых дамб в северном Алжире

Capacity	Number	Hydrographic basin
30	16	Oranie Chott Chergui
3	6	Chéliff-Zahrez
34	28	Algèrois–Hodna–Soummam
14	11	Constantinois–Seybousse–Mellègue

Table 3. Recycling of wastewater from the 4 regions of northern Algeria
Таблица 3. Повторное использование сточных вод из 4 районов северного Алжира

Total Algérie du Nord	Constantinois Seybousse– Mellègue	Algèrois–Hodna–Soummam	Chèliff-Zahrez	Oranie Chott Chergui	Regions Designations
550	140	230	90	90	Wastewater treated in m³/ year, Horizon 2020

out by the Hydraulic Service of the Boukourdane Dam (Algeria) have made it possible to increase the volume of the alluvial water table in the Oued El Hachem plain. The water table also rises at key points,so the bottom outlet discharge process has a positive effect. How to define the optimal water storage strategy Finding better storage sites is essential, and such strategies require a combination of different sizes of surface storage systems and groundwater recharge. Combining the two options requires knowledge of the local hydrology and hydrogeology and the presence of suitable aquifers for water storage.

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Изменение климата и нехватка водных ресурсов в Алжире

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Аннотация

Актуальность данной работы обусловлена важностью воды в продолжении жизни человека и ее большой ролью в осуществлении различных видов деятельности, которые касаются промышленности, сельского хозяйства и различных областей.

Методы исследования. Растущий дефицит водных ресурсов в результате уменьшения количества воды, доступной для человека, сокращение количества целей экономического и социального развития, навязывают разработку и определение стратегии управления водными ресурсами в среде в долгосрочной перспективе. В последние годы кризис нехватки воды увеличился и усугубился из-за волны засухи, от которой страдает регион, и это очень сильно на него повлияло.

В результате исследований можно заключить, что к 2025 году будет зафиксирован дефицит в один миллиард кубометров воды. Возможно избежать этого дефицита в гидрографическом районе Константина – Сейбусе – и это благодаря плотинам, которые находятся в процессе завершения строительства. Для устранения дефицита воды в регионе необходимо увеличить объем хранилищ в плотинах и установить в нескольких районах опреснительные установки для повторного использования сточных вод. Мы также можем избежать нехватки воды, построив небольшие плотины и горные водохранилища, чтобы избежать заиления больших плотин. Решение данной задачи включает увеличение ресурсов поверхностных и подземных вод, поиск новых ресурсов, борьбу с потерями и улучшение качества имеющейся воды.

***Ключевые слова*:** вода, плотины, водный ресурс, климат, подземные воды, эвапотранспирация, опреснение.

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