Larhyss Journal, ISSN 1112-3680, n°60, Dec 2024, pp. 297-308

CAN WE ENSURE WATER SECURITY IN THE ERA OF CLIMATE CHANGE?

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Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received January 2, 2024, Received in revised form November 25, 2024, Accepted December 3, 2024

ABSTRACT

This article provides some clarifications to the question posed in the article title. It is tough to ensure Algeria's water security in a climate that is relentless on water resources. The first victims of this climate are none other than surface water and consequently the drying up of dam lakes. It is necessary to note the abusive use of billions of m^3 per year of water, that the subsoil provides, by the different economic sectors. The drinking water supply of 45 million inhabitants, the irrigation of thousands of agricultural hectares, the exploitation of mega mining deposits, and an evolving industry need billions of m^3 per year. Threatened by exhaustion, the natural reservoirs of the subsoil of northern Algeria are under pressure and the use of artificial water (desalination water from seawater) becomes essential. This is a solution, but it is insufficient. In such a situation, the obligatory use of deep water from the Sahara can alleviate the thirst of today's Algeria, which needs more than 20 billion m^3 of water each year.

Keywords: Algeria, Water security, Desalination, Groundwater, Dam, Evaporation.

INTRODUCTION

Earth is a salty planet, the total volume of water on this planet has been estimated at 1.4 billion km^3 of billion cubic meters—a relatively stable volume over time. Approximately 97.5% of the water is salty and is found in the oceans and seas. Only 2.5% is freshwater of this total volume, or approximately 35.2 million billion m^3 (Futura, 2024). As for the freshwater accessible and available for the production of drinking water, human use does not exceed 0.7% of freshwater (WIC, 2024). Today, the number of inhabitants on planet Earth exceeds 8 billion, a number that requires a water demand much higher than the volume of fresh water available and intended for the Earth. What a misfortune, in addition to this deficit in drinking water affecting the planet, the climate is becoming increasingly disrupted. North Africa and the countries of the Mediterranean basin are the regions most affected by these climatic disturbances. Algeria is not spared by this sick climate. Today in Algeria, everyone is talking about the climate, whether scientists, politicians, the media, even the population. The effects of this sick climate on water are harmful and can even cause serious water shortages. These climate changes are so rapid that adaptation becomes a delicate step to achieve. This new climate consists of a long period of drought that can sometimes reach 7 months and a short-wet season (Remini, 2023). The dry season is characterized by high temperatures that can reach 45 °C in the Algerian Sahara and much longer droughts. This causes a strong evaporation of the water bodies of the 82 dams in operation. This has caused a significant amount of water to return to the sky in the form of vapor; this is called the evaporation phenomenon. These are large masses of water vapor that formed during 6 to 7 months of drought. Once in the atmosphere, these quantities of vapor form clouds that will fall back in the form of torrential rains that will trigger flash floods during the short-wet season. These floods drain significant quantities of sediment that will be deposited at the bottom of the dams, the silting up of the dams is accelerating with climate change. Today the useful volume of the dams is threatened by a double reduction: by silting up and by evaporation. Even the use of groundwater has not spared the population's thirst. The static level of the water table is moving further and further away from the entire Algerian territory. This has caused several wells to dry up. As for coastal aquifers, the rapid lowering of the water table has caused salt water to flow into the fresh water of the water table, thus causing a density current that gradually moves away in the water table and becomes polluted from north to south. All the aquifers on the Algerian coast over a length of 1,200 km are threatened by the phenomenon of marine intrusion. The example of Oued Nador in the wilaya of Algiers is a serious one, since today the coastal aquifer is salty due to the advance of the salt wedge into the groundwater (Bouderbala, 2016). Algeria has been turning to the sea to desalinate these waters since 2000. Today, Algeria has 14 seawater desalination plants producing 2.2 million m^3/day. If today, desalination is the only water sector that has made serious progress, however, brine management is at an embryonic stage. Ensuring Algeria’s water security requires an innovative strategy by proposing new solutions.

FRESHWATER STOCK

Before discussing a country's water security, we must first determine its freshwater stock. However, it turns out that today, our freshwater stock remains unknown. As a result, several experts have been saying for years that Algeria is considered a country with water stress. What criteria are used to determine this classification? No one can answer this question without knowing a country's freshwater stock. The latter consists of conventional and non-conventional waters existing in a country, namely surface water contained in dams and hill reservoirs, groundwater, desalinated seawater, purified water and agricultural drainage water. In this freshwater stock, there is the volume of freshwater accessible to humans and which requires material resources from each country.

WATER SECURITY AND CLIMATE CHANGE

Answering the theme of the article directly in the affirmative is utopian. With a sick climate that is contaminating all water resources, whether surface water or groundwater, and it has even forced us to drink artificial water (desalinated water and purified water). All water storage reservoirs, whether artificial (dams) or natural (aquifers), are now threatened by the exhaustion syndrome. The dams that were the flagship of Algeria's hydrotechnics during the 1980s have now become incapable of quenching the population's thirst. It should be noted that with this climate, all dams in operation may experience a drying up of their water reservoir, particularly low and medium capacity dams. Such a situation will accelerate in the short and medium term. No dam will be safe from this drying up phenomenon. As a reminder, this disastrous situation began about twenty years ago with the Keddara dam in 2000 and then in 2022 (Fig. 1), followed by the dam (Annaba) in 2006, the Tlemcen dam, the Bakhadda Tiaret dam (2023), the Foum El Gherza dam (2024) (Fig. 2), the Boukourdane dam, the Djorf Torba dam (Bechar), the Kouidet Acerdoune dam which is now filled to 2% of its initial capacity of 640 million m^3.

Figure 1: Keddara Dam. Dam not silted up but dried up? During the period 2000-2024, the level of the dam reaches 3 times the dead volume (Photo Remini, 2024)

Figure 2: Foum El Gherza Dam. Dam silted up and dried up? For 6 years, the water level of the dam has been at dead volume (Photo Remini, 2024)

It should be noted that already in the early 2000s, we highlighted the problem of evaporation of dam lakes in Algeria (Remini, 2005). The drying up of dam reservoirs is a new option or a new characteristic that belongs to the dam and that will directly influence the aquaculture that is developing in dam lakes. Therefore, it is necessary to avoid developing aquaculture in dams of low or medium capacity. The period of dam drought can be an opportunity to maintain the dam and take advantage of the fact that the dam is empty to carry out mechanical dredging operations. Such an operation can be less expensive than hydraulic dredging. But the problem still arises for the place of discharge of the discharged sludge. The original solution to the silting up of dams is the recovery of the silt in the following areas: agriculture, construction (bricks, tiles and cement) and pottery according to the results of the analyses carried out on the silt samples (Fig. 3).

Figure 3: Vase from the Foum El Gherza dam removed and stored in a basin, a raw material for the manufacture of building materials and pottery (Photo. Remini, 2024)

It should be remembered that we were the first in the world to discuss this solution in the late nineties and early two thousand years. Unfortunately, at the time, the hydraulic services did not appreciate such a proposal to mitigate silting. Several articles were published in several journals. About ten master's degrees and end-of-study projects were supervised and supported (Remini, 2006). Otherwise, chemical, physical and mineralogical analyses of the silt are negative, the silt will be discharged into the wadi downstream of the dam if the latter is located on a watercourse that discharges into the sea. In this case, the silt returns to the sea which is normally its place of deposit before the construction of the dam. But the fairest solution and which can slow down the silting of dams is undoubtedly to retain these sediments at the level of the watershed by the development and reforestation of the watersheds. Raising the dam by a few meters can increase the life of the dam (Remini, 2008). Not to mention the good management of the drainage channels when floods arrive can increase the age of the dam (Remini, 2017).

When artificial reservoirs are thirsty, the population turns to natural reservoirs in the subsoil and exerts unprecedented pressure to meet the demands for drinking water and irrigation. Everywhere, the ground is pierced by short or deep boreholes in search of water hidden in the subsoil (Fig. 4). Unfortunately, we have no idea of the number of these boreholes in service or the distance between the boreholes. Thus, it is time for the hydraulic services to draw up a map of the boreholes to have an idea of the number, the flow rate and the optimal distance between two boreholes. Having an idea of the total flow rate drawn makes it possible to deduce the depletion of the water table knowing the flow rate of the water table replenishment.

Figure 4: A water borehole in the middle of the Grand Erg Oriental (Oued Souf) (Photo Remini, 2024)

The question that arises is why are dams the most fragile in the face of climate changes? Quite simply, the useful volume of the dam will have a double decrease. In times of drought, a decrease in useful volume arises from above following the strong evaporation caused by high temperatures. In times of floods, a decrease in useful volume arises from below following the rapid deposits of sediment at the bottom of the dam (Fig. 5). The origin of this mud comes from the mountains of the watershed and the watercourses. It is the floods that cause soil erosion and the undermining of the banks (Figs. 6 and 7).

Figure 5: Fergoug Dam Lake filled with mud. Dam silted up to 85% of its initial capacity (Photo Remini)

Figure 6: A view of soil erosion in the Algerian Biskra city (Photo Remini 2024)

Figure 7: The importance of the undermining of barges at the level of the Labiod wadi having an impact on the silting of the Foum El Gherza dam (Photo Remini, 2024).

These floods, more loaded with fine particles once in contact with the waters of the dam reservoirs, cause the formation of density currents which propagate on the bottom of the dams to reach the foot of the dam. These significant quantities of fine particles settle and consolidate once the drainage openings remain closed. Climate change will accentuate the formation of these density currents in the dams in the years to come (Fig. 8).

Figure 8: Density current in a rectangular channel. This is the same phenomenon that forms in a water dam (Photo Remini)

This new situation that has just emerged in recent years marked by the drying up of dam lakes is creating terrible pressure on underground water tables. This is the only path that remains valid during climate change. As we have mentioned several times, groundwater is the only water resource that will be spared during climate change. So, countries that have water reservoirs in their subsoil will be the safest countries that resist climate change. It should be noted that the African continent is the only continent that contains large aquifers in its belly (Remini, 2021).

As we mentioned previously, the drying up of some dams has frightened the population since these reservoirs have been the flagship of Algeria's water security since Independence. Whether it is irrigation or drinking water supply, the dam was the only benchmark for a dry or rainy season. Everyone makes the connection between a successful agricultural season and the filling of the dams. Since the year 2000, there has been a period of drought that was strongly felt by the population. At the time, the Keddara dam, which was considered the water tower of the capital, saw its useful volume drop to reach its volume equal to zero under the effect of evaporation. The few drops of water remaining at the bottom of the dam, which corresponds to the dead volume, were sucked up by a small floating pumping station to quench the thirst of the population of the capital. Unfortunately, this is not the case, since for the first time in Algerian hydrotechnical history, they were unable to meet these demands for irrigation water and drinking water supply. Given this new situation, Algeria has changed course to head towards the Mediterranean Sea which has an infinite volume of water, but of poor quality (salt water). Going towards salty but abundant water is not a choice, but rather an obligation dictated by climate change. It was in the year 2000 after the severe drought that hit Algeria, the hydraulic services definitively opted to clean the sea water. But this delicate option requires cutting-edge technology to remove salt from the sea water and then obtain fresh water (Fig. 9). Adding mineral salts to this distilled water will give drinkable water. To obtain a hundred m^3/d of desalinated water, it is necessary to build an entire plant that costs millions of dollars.

Today, Algeria has 14 seawater desalination plants with a capacity of 2.2 million m^3/day along 1200 km of coastline, an annual flow of 800 million m^3 equal to the volume supplied annually by the Beni Haroun dam. Only these 14 desalination plants discharge into the sea about 2.5 million m^3 of brine per day, or about the discharge into the sea of 900 million m^3/d of brine.

Figure 9: A brackish water desalination plant in southern Algeria (Photo Remini, 2024).

Towards the end of 2024 and the beginning of 2025, five seawater desalination plants with a capacity of 300 million m^3/d will be in operation. Algeria will have 19 seawater desalination plants to produce a volume of 3.7 million m^3/d of drinking water. This requires a discharge into the Mediterranean Sea of a volume of 4 million m^3/d. All countries in the world that produce drinking water from seawater discharge the brine from the desalination plants into the sea. The salt returns to the sea but polluted by the chemicals used in the pre-treatment phase and membrane washing operations. In addition, directly discharging the concentrate onto the seabed as is done in several countries damages the marine environment. Today, the brine must be diluted before being discharged into the sea or simply, establish a map of the seabed that locates the places where the concentrate is discharged to spare aquatic life. The only solution for the brine is its recovery. Once this step is completed (recovery of the brine) we can say that we have achieved sustainable desalination. But such a project requires cutting-edge technology. Another problem that affects the good performance of the desalination plant is the quality of the raw water. This problem has never been raised by desalination specialists. The proof is that all the desalination plants built during the 2000s were installed near the discharge points of the wadis. We were the first to raise this problem and introduce the study of the raw water collection point in the projects to build a desalination plant. It is difficult to build a desalination plant on a 1,200-kilometer coastline, knowing that 50 large wadis that have spread from east to west discharge water loaded with fine particles into the Mediterranean Sea (Remini and Amitouche, 2021).

CONCLUSION

As we mentioned at the beginning of this paper, ensuring a country's water security in climate change is not simple. It requires a strategy with innovative solutions. Apart from seawater desalination, an option that has been taking shape on the ground since the early 2000s and in 2020 the construction of seawater desalination plants accelerated to reach 14 plants with a total capacity of 2.2 million m^3/d and by the end of 2024, Algeria will have 19 plants that will produce a volume of 3.7 million m^3/d. While desalination water increases the stock of fresh water, other water resources such as dam water or aquifer water have not changed. It should be noted that Algeria remains a special and complex case. Indeed, in addition to climate change which harms water resources in the north Africa regions, and the Mediterranean basin, Algeria today has a galloping demography of 45 million inhabitants and a socio-economic development reaching its cruising speed. Algeria has just launched in recent years mega agricultural, mining, industrial, and social projects which require according to our estimates 20 billion m^3 of water per year. Satisfying such demand requires a strategy with innovative solutions.

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