DOI: 10.24850/j-tyca-15-1-8

Articles

Spacing Hinterland Water for Algiers City (Algeria)

Espaciando el agua del interior para la ciudad de Argel (Argelia)

Tarek MEDJADJ[1], ORCID: https://orcid.org/0000-0002-1148-4413

Lahcene FELOUSSIA[2]

M'hammed SETTI[3]

[1]University of M'sila, Algeria, tarek.madjedj@univ-msila.dz

[2]University of M'sila, Algeria, lahcene.feloussia@univ-msila.dz

[3]University of sciences and technology of Algiers, Algeria, settimhammed@yahoo.fr

Corresponding author: MEDJADJ Tarek, tarek.madjedj@univ-msila.dz

Abstract

Of all the kinds of relationship, the one that links man with water is considered as profound and serious in geographical surveys. Yet in the past, the greatest threat to agriculture was a major problem, the attention of people is now captured by water in cities. The increasing need of water

Tecnología y Ciencias del Agua

OPEN ACCESS

Check for updates

in Algiers is due to the growth of population and urbanism. On the other hand, there is a rise in water needs per capita. This problem didn't arise during the last decades, but today the situation is no longer the same. It's a considerable challenge for the capital Algiers, especially for the next generations. Using a geo-history method, which consists in studying the evolution of hinterland water space in time, we will direct our research towards the exposure of the influences exerted by the increase of water needs in the zone of study. The finality of the work is to identify the water resources around the Algiers City and that arises from the spacing of evolution hinterland water. We will obtain valuable information about the extension, the distance of the hinterland water supplier from the city of Algiers. The expected results of this work is to determine the hinterland which can be counted on to supply the city of Algiers with drinking water in the medium and long term. Finally, we can think of hydraulic planning and development based on the principles of sustainable development. This with the aim of proposing solutions to current problems and ensuring the needs of future generations.

Keywords: Algiers, City, Water, Hinterland

Resumen

De todos los tipos de relación, la que une al hombre con el agua es considerada como profunda y seria en los levantamientos geográficos. Sin embargo, en el pasado, la mayor amenaza para la agricultura era un gran problema, la atención de la gente ahora es capturada por el agua en las ciudades. La creciente necesidad de agua en Argel se debe al crecimiento demográfico y urbanístico. Por otro lado, hay un aumento en las necesidades de agua per cápita. Este problema no se planteó durante las últimas décadas, pero hoy la situación ya no es la misma. Es un desafío considerable para la capital Argel, especialmente para las próximas generaciones. Mediante un método de geo-historia, que consiste en estudiar la evolución del espacio hídrico del interior en el tiempo, orientaremos nuestra investigación hacia la exposición de las influencias ejercidas por el aumento de las necesidades hídricas en la zona de estudio. La finalidad del trabajo es identificar los recursos hídricos en torno a la ciudad de Argel y que se derivan del espaciamiento de la evolución de las aguas del interior. Obtendremos información valiosa sobre la extensión, la distancia del proveedor de agua del interior de la ciudad de Argel. El resultado esperado de este trabajo es determinar el hinterland con el que se puede contar para abastecer de agua potable a la ciudad de Argel a medio y largo plazo. Finalmente, podemos pensar en la planificación y el desarrollo hidráulicos basados en los principios del desarrollo sostenible. Esto con el objetivo de proponer soluciones a los problemas actuales y velar por las necesidades de las futuras generaciones.

Palabras clave: Argel, ciudad, agua, traspaís

Received: 11/02/2022

Accepted: 03/07/2022

Introduction

During the last decade, climate change has been acknowledged as one of the primary concerns of development on a local and regional scale, as well as on an international scale. Precipitation in North Africa is likely to decrease between 10 and 20%, while temperatures are likely to rise between 2 and 3 °C by 2050 (Schilling et al., 2012). For the North African countries, in Algeria particularly, the question of water supply is a big challenge for public authorities. It is among the countries in Africa that suffer from water shortages. The rapidly growing water demand in the Maghreb countries is forcing national authorities to build more dams in order to increase the available water resources which are naturally limited, and to face the strong temporal irregularity of rainfall (Remini, 2009).

Most evident in this shortage is the suffering of urban residents' communities to obtain safe drinking water. The capital (the largest city in the Maghreb) was not more fortunate compared to other major cities in this area, as it suffers from scarcity for two reasons: the first is due to a large demographic growth, and the second is due to the increase in the daily needs of water. In addition to the growing demography, 60% of the population resides in the northern range of Algeria, which represents one tenth of the total area of the country. Furthermore, inadequate water treatment due to a lack of appropriate technology, siltation of existing

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

dams and limited capacities for water storage hamper the decision-making process (Boudjadja et al., 2003).

In 2008, although the rate of drinking water in the capital is close to the full rate (100%), that is, it is comparable to the rates of developed countries more than the rates of countries that we usually compare ourselves with, but the main problem that the city suffered from for many years was an interruption due to the drying periods like this 3rd last year (Figure 1). The drought recorded during the past four years has had no equivalent, neither in duration nor in intensity over all the northern regions of Algeria. The study of drought persistence, using Markov chains, showed that, to have a non-dry year after a dry year, the probability is greater in the centre of the country than in the west (Meddi & Meddi, 2009).

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

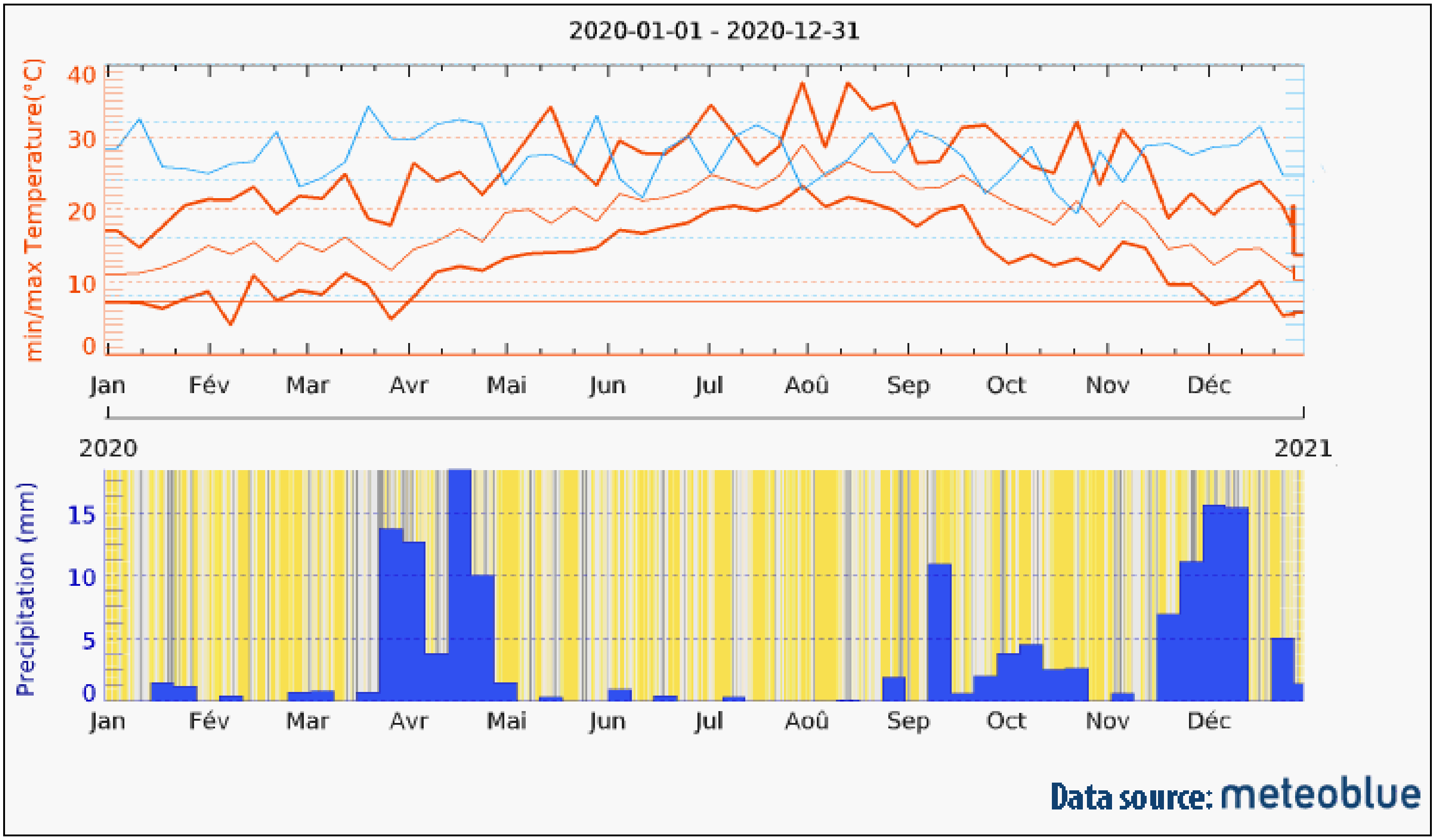

Figure 1: The drought and drying periods in Algiers City (2020)

Otherwise, the problem also arises at the distance and spacing of supply sources, in particular with the wave of drought that is hitting northern Algeria. This led us to study the evolution of the remoteness of the sources of water supply in Algiers with a view to remediating the water crisis in this city in full growth. The water problem in the capital is a perfect illustration of the arbitration conflicts between an area that requires and consumes a lot of water, without its own resources, and its hinterland (Chikher-Saidi, 1997).

Our work is structured in title and subtitle bearing the different fluctuations of the water hinterland of the Algiers city. The sources of supply is the only criterion used in the analysis of this functional space.

We started with an introduction to identify the problem of the remoteness of the hinterland water. In the next section, we presented the data collection method and the analysis tools used. The results were presented in the form of diachronic titles according to the time of evolution of the phenomenon studied by integrating the analyses resulting from the field data. At the end, we concluded by proposing recommendations to solve the water management problem first before going to the technical problems.

Research method

The city of Algiers is located on LL: 36° 46′ 34″ North, 3° 3′ 36″ East (Figure 2). It is the capital of Algeria and the most populous city in North Africa with nearly 7,796,923 inhabitants according to data from the national statistics office.

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

Figure 2: Location map of Algiers city. Data source: World map, consulted 12 May 2022, URL: http://www.carte-du-monde.net/pays-12-carte-relief-algerie.html

The growth of Algiers accelerated from the 1970s, with the consequences of the aggravation of the challenges in terms of housing, equipment and urban services (Santos, 1971). Evidently, the drinking water supply is considered an urban service which must be provided by the public authorities.

Using data of the National Water Resources Agency, we will make an inventory from the water supply sources for the city of Algiers and its hinterland to several periods. The beginning was from ottoman period and then colonial and we have focused our analyses after independence period.

Two types of qualitative methods were used, both of them are complementary. The first consists in carrying out visits in-situ to a sample of the dams. Secondly, we took this opportunity to make semi-direct inquiries with those in charge of these plants and of the hydraulic sector in particular. The objective of these surveys is to strengthen our analysis by providing up to date information on the functioning of water transfer operations from hinterland space to the city of Algiers. We also compared the field data with those of official institutions to avoid all the agreed discourse coming usually from public authorities and to look for the real problems linked to the water supply in Algiers City.

Non-geographical methods are often used in the field of water (Graillot, 1986) but they target the development of objectives adapted to a parcel management of water and not in the case of a large scale. It is for this reason that we have opted for the use of an analysis method based on geo-referenced data integrated into a geographic information system (GIS). GIS are means of presentation and interpretation of facts observed on the earth's surface (Tomlin, 1990). The transformation of data by a GIS aims to extract the implicit spatial relationships contained in the data origin (Lanter, 1992). The information obtained from field will be mapped using GIS tools to modeling the distance and evolution of spacing the hinterland water. Falcidieno et al. (1992) insist on the need for a level of high abstraction to describe reality. We have used the open source *Qgis* software for methodological considerations as well as these spatial analysis capabilities. The difficulty of delineating the hinterland is solved with the *Buffer* tool by fixing the centre of the city of Algiers as a reference point. Subsequently, analyses were carried out by draping the layers of water resources (wells, dams, wads). This allowed us to identify results explaining the remoteness of the water hinterland. But also, the excessive cost of 1m^3 of drinking water. This leads us to think about strategic planning for the future with an adequate vision in relation to existing reserves and constantly changing needs.

Direct Hinterland: the supplied water until the mid-1960s

It was the source of water until the mid-eighties in the seventeenth century. Algiers was famous by having one of the best drinking water supply networks in the Mediterranean basin. Thanks to the immigrants coming from Andalusia, who applied high-level water transportation techniques, the Ottoman leaders used them to establish four (4) aqueducts deliver water from the heights city of Algiers (*Ben Aknoun, Bouzareah, Abyar*) to the coast and centre city with a capacity of more than two million liters per day (Raymond, 2014). The aqueducts of Algiers are not only the seat of a gravity flow to the Roman, because they involve

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

works whose function is closer to a flow, which happens under pressure and mechanical control. This technique suited to hilly lands has its origin in Constantinople and finds application in Algiers (Kameche-Ouzidane, 2013). In addition to this network, the capital had several public fountains, public wells and personal wells inside homes (Figure3).

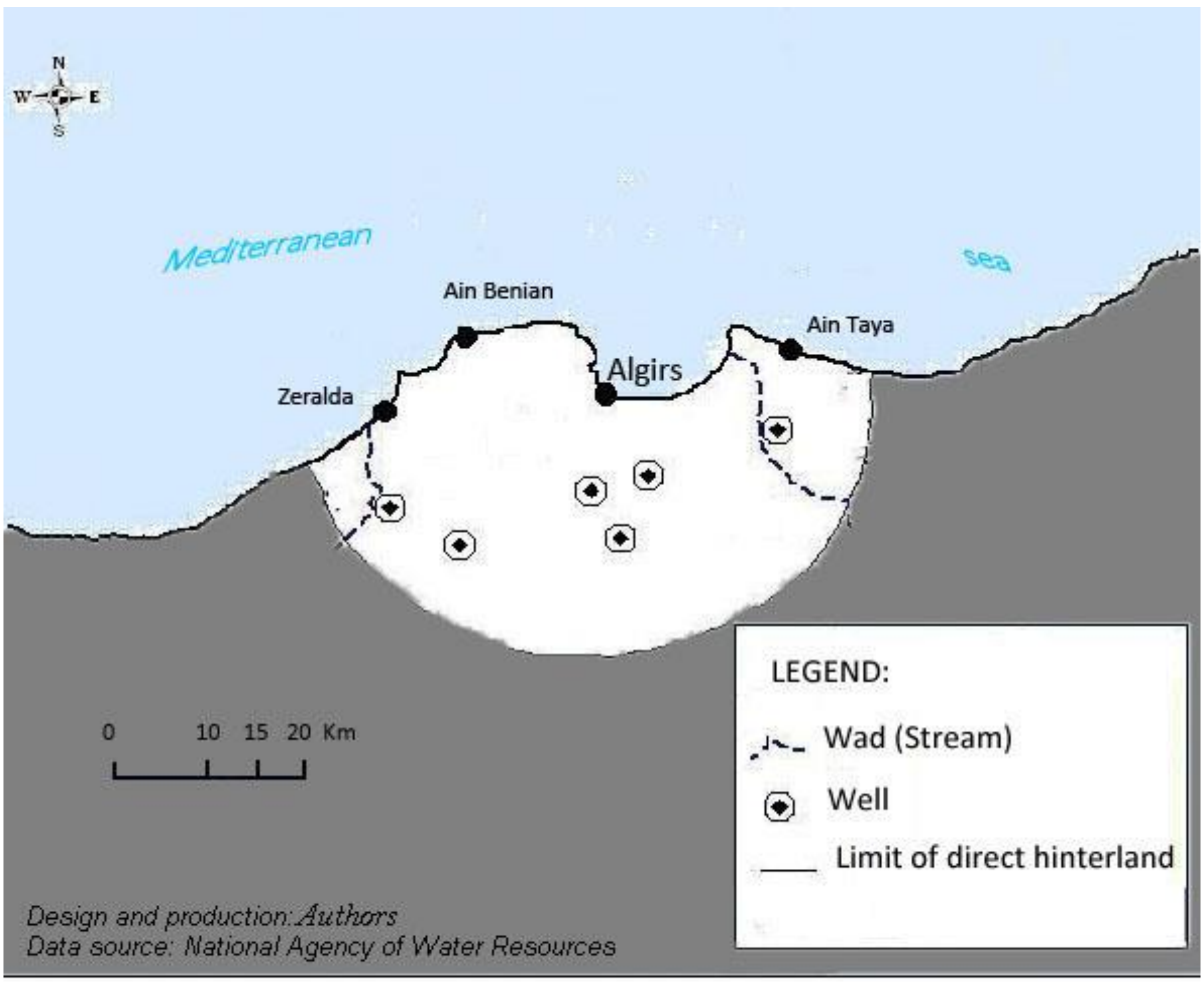

Figure 3: Direct hinterland water of Algiers City (before 1962)

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

Due to the effectiveness of this network, the French colonists used it until 1866, and over to all these sources, the water element was abundant in that period (Tvedt & Oestigaard, 2016). With the spatial expansion and urban development that the city of Algiers witnessed during the occupation, the French authorities intended to meet the increasing demand for water to connect channels to bring water from the *Mzafran* Basin (southwest) and from some wells spread in *Mtijah* plain (south).

Algiers inherited this system after independence, and to say the least, it met the daily needs of the capital's residents and their modest horticultural and industrial activities. Until the mid-eighties, the city was totally dependent for its water resources on the water of the underground wells scattered in its south, direct hinterland.

After independence (1962): The inevitable supply from the middle hinterland

The capital's residents witnessed a very difficult period at the beginning of the eighties, as the increase in demand for water coincided with a decrease in its production, as many wells spread south of the city were unable to meet the required quantities. And everyone was eagerly awaiting the completion of the new dam, which is about 35 km east of Algeria (Figure 4).

Here begins a new phase in the history of supplying the capital with drinking water, which is the stage of bringing water from the middle hinterland. The *Kaddara* Dam entered the production stage in 1987, and citizens and officials were optimistic, and considered it as a radical solution for the problem in Algiers. The dam, which is located on the territory of the *wilaya of Boumerdes* (Figure 4), was built on the *Boudouaou* Valley with a storage capacity of 145.6 million square meters, which is considered to be sufficient to cover the residents household needs and their daily activities. In addition to the water of the valley on which it is built, the water of valley Yasser favors to the *Bani Omran* Dam and the water of valley-Al-*Arbatash* bring to the *Al-Humayz* Dam, which has a capacity of 16 million m^3 each. Starting from this date (1990), then, the city became dependent on surface water mainly to supply it with drinking water (55%) according to the National Water Resources Agency.

Ten years have passed since the *Kaddara* Dam entered production until the capital knew its first plan for the rescue. After years of drought and after citizens thought that an era had passed, never to return. This plan was approved in April 1997 and was in effect until 2008. During these years the population experienced a great fluctuation in the distribution of water. This depends on the fluctuation of the annual amount of precipitation and the fullness of the dams: from one in three days (1997, 2000 and 2002) to one in two days (1998 and 1999) to a daily distribution (2003).

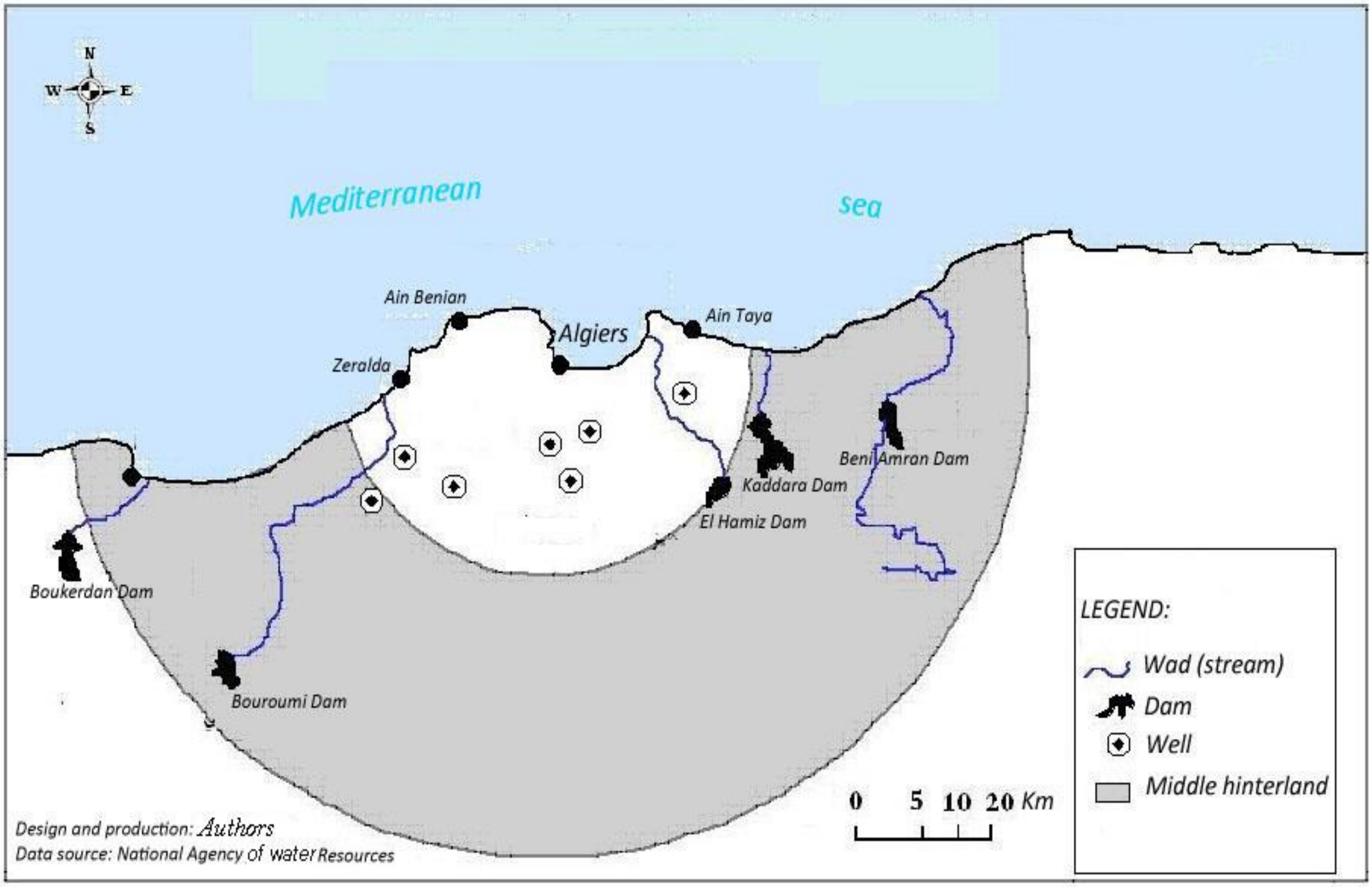

Figure 4: Middle hinterland water of Algiers City (1990)

The responsibility for approving the rescue plan or raising it in the capital based on the opinion of the state technical committee, which studies all possibilities based on four elements: The amount of water stored in the dam (*Kaddara*), the volume of well water, groundwater level, and finally, future climatic conditions (precipitation).

Tecnología y Ciencias del Agua

OPEN ACCESS

Check for updates

In light of studying these variables, the technical committee decided to provide residents of the capital with water daily, one day in two days, or one in three days, improving or reducing the timing of distribution (4, 8 or 12 hours per day).

The relief plan was not raised due to the big difference between the daily amount of water produced and the daily needs, which were estimated at that time at 650,000 cubic meters. The residents of the capital supply one day in 3 days if the amount of water produced per day decreases within 360,000 m^3, and to increase the distribution period to one day in two days, 450,000 m^3 must be produced per day.

Approving the rescue plan of supply (2000)

Under the triple shock of drought, pollution, the spectacular growth of needs resulting from the increase in population and urban growth, the natural resource that we believed to be inexhaustible, available forever, becomes a scarce economic good (Mutin, 2000). In the 2000s, Algiers experienced a state of strong water stress: insufficient or impaired sanitation and water distribution systems. There is no doubt that the precipitation factor has a major role in the water balance. In the wake of droughts that affected the region between 1990 and 1995, the water reserve of *Kaddara* Dam fluctuated. Higher temperatures will produce higher evaporation rates so increasing aridity even if precipitation stayed the same (Sutton & Zaimeche, 1992). The rescue plan is imposed only if the amount stored in the *Kaddara* Dam falls below 70 million m³, which is less than half of its total storage capacity.

And what made the situation worse the amount of water diverted to the main dam (*Kaddara*) decreased, and the number of unlicensed wells in the region belonging to the agricultural and industrial sectors doubled, which negatively affected the production of the wells supplied to the capital, especially in the *Mtijah* plain. However, most dams are subject to a loss of capacity due primarily to three factors namely: water leakage, the silting and evaporation intense (Abid et al., 2019). In addition to the precipitation factor, there was a degraded situation characteristic of the city's distribution process, which was the loss of huge quantities of water. So 15% of the produced quantity is lost during conversion and 40 to 50% of it is lost inside the networks, bearing in mind that the acceptable average loss should not exceed 15 to 20 %. Is it reasonable to allow such a quantity lost in a time of scarcity? The outdated fashion of water conveyance and insufficient storage capacity hinder the correct distribution of water to the consumers (Kadi, 1997).

The high level of extravagance shows the overwhelming chaos that prevailed in the sector of water production and distribution and its management in the city of Algiers, and this situation can be explained by at least two reasons:

- Corruption of water distribution channels, as most of the distribution networks are still those established by the colonizer (more than 60 years old). It must be noted here that the city inherited one of the most complex

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

distribution networks in the world, due to the severity of the surface bending the passage of water through the channels causes it to have strong pressure, which reflects negatively on it over time. Algiers Water and Sanitation Company (SEAL), which ran 1,800 km of canals for 250,000 subscribers and it, recorded more than 20,000 damages and water losses per year (Hamadache, 2021).

- Bad management of the institutions in charge of water production and distribution, and lack of rationality. These institutions have not yet moved to scientific management methods which consider water an economic commodity and a rare resource. It is subject to effective and efficient management methods, and the best example of this mismanagement is the great chaos that prevailed in the pricing and water bills.

Aware of these challenges, the Algerian government decided in 2006 to raise the network's performance to the level of international standards and to modernize the governance of water management in Algiers. Today, the problem has not been resolved.

The summer of 2021 saw an unprecedented drinking water supply crisis. Accessibility to this service is not fair for all the districts of Algiers. Disturbances in the distribution have been noticed due to the low pressure system which only reaches the 5th floor (Hamadache, 2021). Water has become a dream for some neighborhoods. "Our dream is to see water flowing through our taps" where a resident has expressed his need during our field survey in summer 2021.

Tecnología y Ciencias del Agua

OPEN ACCESS

Check for updates

The future water resources of the capital

The technical studies prepared between the years of 1979 And 1980 showed that the water supply capacity of the latter to the residents of the capital will become insufficient, starting from the 2000. The planners at that time relied, in their studies of the prospects for the population and urban development, on the annual growth rate extracted from the period between the 1966 and 1977 censuses, which was estimated at 5.56% (MEAT, 1997). Fortunately for the citizens, this rate has decreased considerably since that date to stabilize within the limits of fewer than 2% during the decade (1990-2000). This situation will expand if the program is used to explore the resources of remote hinterland water, which has become inevitable in the medium and long term. However, the extension of agricultural land is linked with the water supply. In the beginning, the irrigation was done from dams (gravity irrigation) and requires a large amount of water but with the drought experienced by Algeria in the years (1970, 1989, 2000), the percentage of water intended irrigation was decreasing and has been directed for supplying cities (Djaffar & Kettab, 2018).

Determine the field of the far hinterland

We cannot define and determine the distant hinterland (More than 70 km) except within its natural water range. The hydrological characteristics of the surface flow which have been taken into account are climatic parameters and physical parameters (Touazi et al., 2004). That is, through a basin or group of aquariums. In this context, a quick comparison of the water basins surrounding the city of Algiers (Figure 5) shows that the eastern and southeastern regions of the capital are more fortunate than its western counterpart capital.

Table 1: Hydrological characteristics of the eastern and western basins of the capital

Sum Water Resources billions m³	**Underground water resources billion m³**	**Surface water resources Billion m³**	**Area (km²)**	**The amount of precipitation is billion m³ / year**	**Aquarium**
4.920	**0.620**	Algeria - Yesser-Spaw: **3.10**	**47 900**	**21.2**	Algeria Soumam elhodna
2.245	**0.245**	Chlef-Dhahra: **1.70** Zhariz: **0.30**	**56 200**	**20.5**	Chlef Zahariz

Data source: National Agency of Water Resources

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

The large water basin providing the capital with drinking water in the medium and long term was designated and defined his limit by an implementing decree in August 1996 called Basin Algeria-*Soummam-Hodna*. It is one of 5-water basins covering the national territory (Table 1).

This basin includes 12 million people (ONS, 2008), or 35% of the total population of the country. It administratively covers 6 wilayas altogether (*Algiers, Blida, Boumerdes, Tizi Ouzou, Bouira and Bordj Bou Arreidj*) and 8 wilayas partially (*Tipaza, Medea, Ain Defla, M'sila, Djelfa, Bejaia, Setif* and *Batna*. It represents in a group of 1,390 localities divided into 491 municipalities. The amount of precipitation over the entire basin reaches 2.21 billion m^3 per year (AGEP, 1995). While the total surface running water is estimated at 4.3 billion m^3 .Underground water is also estimated at 0.6 billion m^3. Part of the surface water is stored by 10 dams with a capacity of 655 million m^3. But they produce an annual average of 422 million m^3, and four (4) other dams are in the process of being built with a storage capacity of 1.1 billion m^3 (AGEP, 1995).

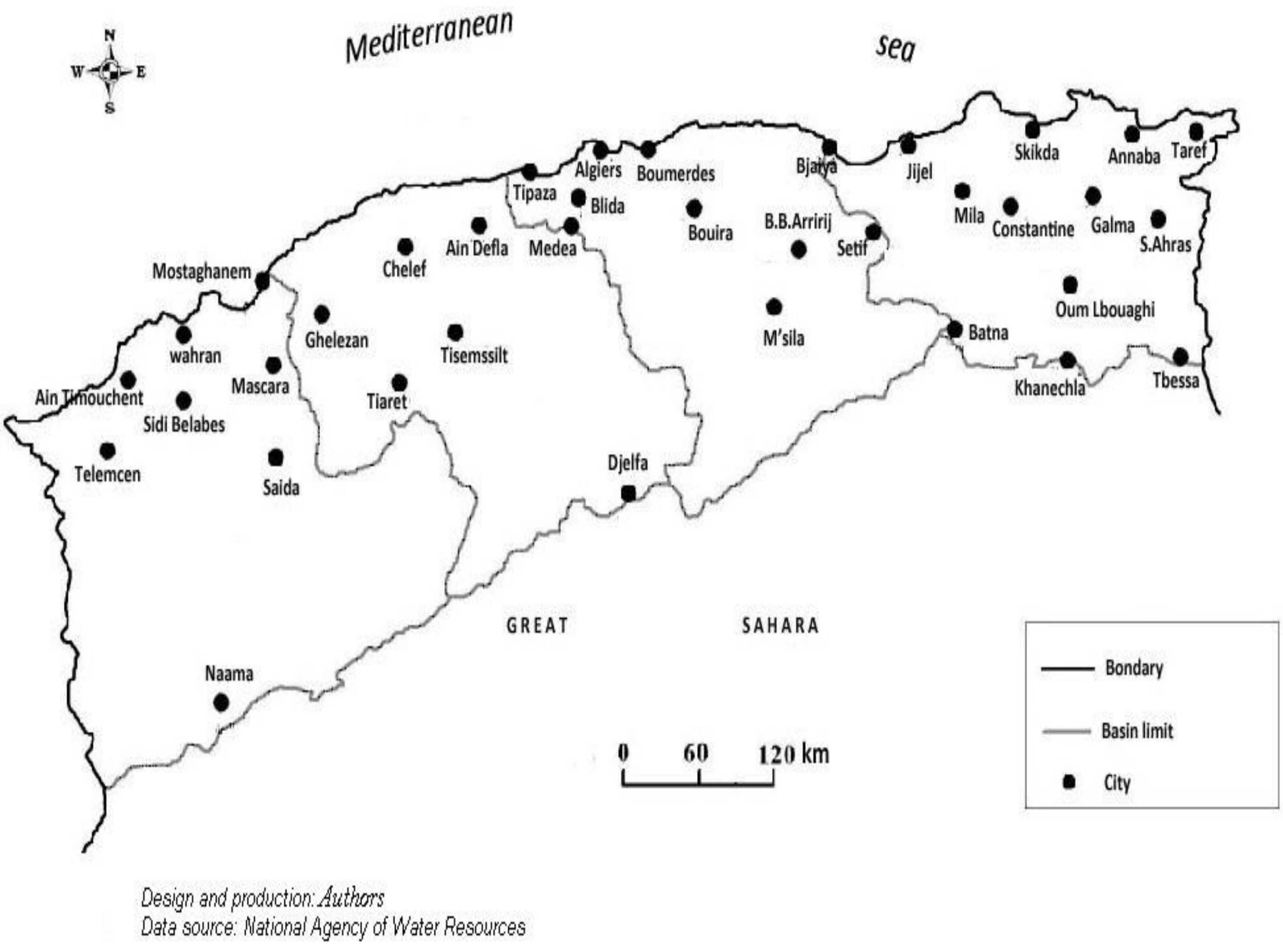

Figure 5: water basins surrounding Algiers City

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

Tecnología y Ciencias del Agua

OPEN ACCESS

Check for updates

The capital's water future will be in its far hinterland

The authority responsible for supplying the capital with drinking water has prepared an ambitious program in the medium and long term. In addition to greater exploitation of the underground water located on the direct front by the completion of 22 additional wells in the *Mtijah* plain, which allowed the collection of an additional 50,000 m^3 of water per day (Safar-zitoun, 2019). In 2002, three dams located on the western side of Algeria were linked between them by water delivery channels to the end of the capital, to benefit from the surplus known by these dams, which are: *Boukrdan* Dam: diverting 23 million m^3 annually out of the 46 million m^3 stored in it. *Gharib* Dam: diverting 17 million m^3 annually out of the 70 million m^3 stored in it. *Borumi* Dam: diverting 9 million square meters annually out of the 19 million cubic meters stored in it (MEAT, 1997). This connection project allowed the city of Algiers to benefit from 58 million m^3 annually without inflicting any shortage on the already-increased population of the three dams. Increasing groundwater wells and connecting nearby dams that have surplus water to the capital are nothing but an emergency program set up to cover the recorded deficit. As for the medium and long term, he was relying on three dams that were programmed to supply the capital with drinking water, all of which are located on the eastern side of its watery back. Two of them are located at the far hinterland, and the third will be built at the middle Hinterland to reinforce water-producing facilities (Figure 6).

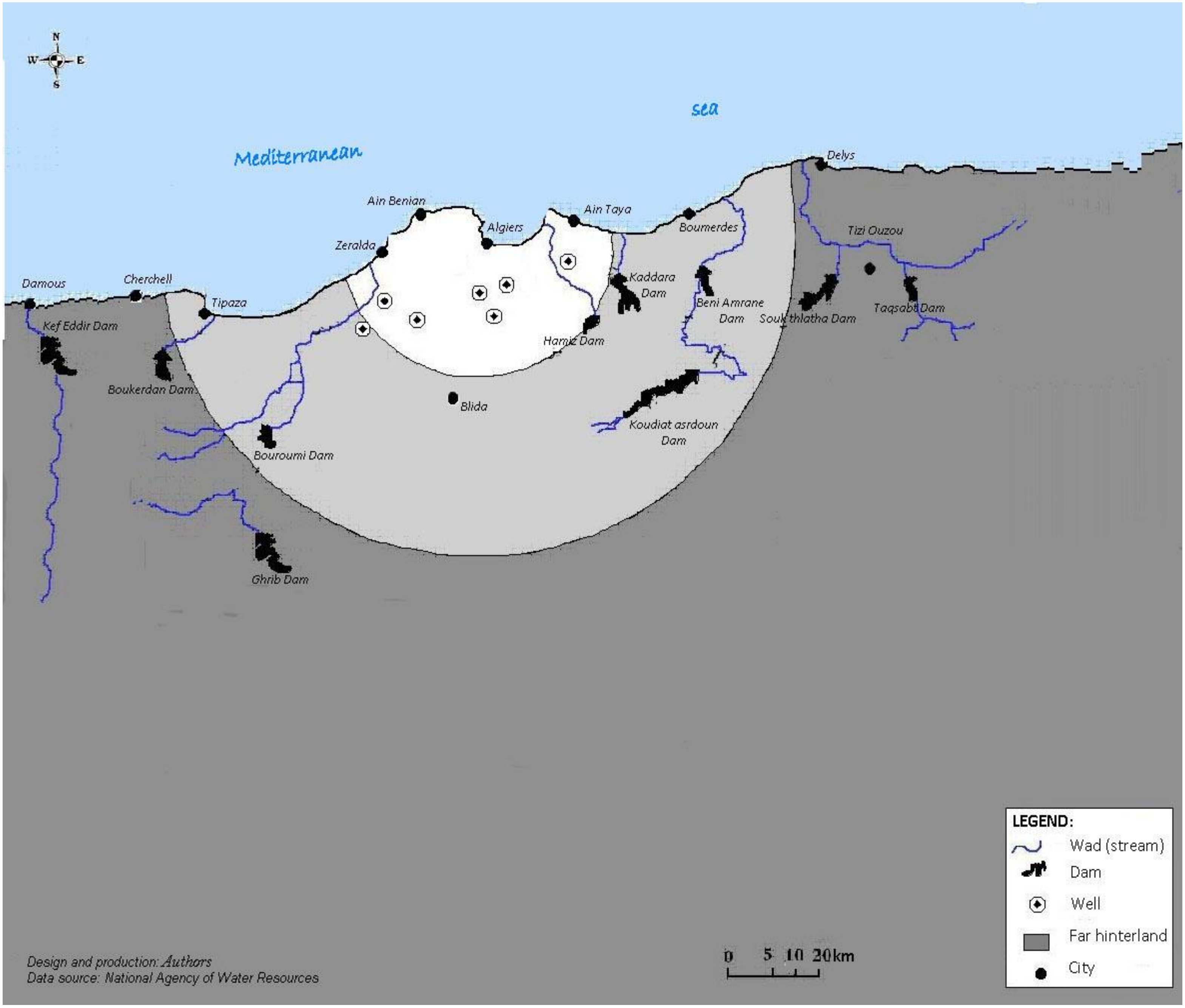

Figure 6: Far Hinterland Water of Algiers City (2015)

Taqsbat Dam was built at the far hinterland of the *wad Issa* in the wilaya of *Tizi Ouzou* (100 km east of Algiers). This valley receives rainwater from the *Jarjara* Hills, which flows into the *Sebou* plain then to the Mediterranean Sea. Works began on it in 1993, but due to the bad security conditions in this zone, the project was not completed until the end of 2007 (Benbelkacem & Benallel, 2002). It did not enter the actual production stage until March 2008. The storage capacity of this dam is estimated at 175 million m^3 and the amount that is supposed to be transferred annually to the capital is 73 million m^3 *Koudia Asardoun* Dam which is located on the wilaya of *Bouira* at the middle hinterland of Algiers, Work on this dam did not start until 2002 and was completed only in 2008. Its storage capacity reaches 636 million m^3, but the quantity that is expected to be collected in it does not exceed 146 million m^3 per year. It is the second-largest dam in Algeria after the *Bani Haroun* Dam (Mila). He shall not participate in supplying the capital until the year 2012, with an annual amount estimated at 50 million m^3 (Benbelkacem & Benallel, 2002). The rest is supplied by four other wilayas: *Medea, Tizi Ouzou, Bouira* and *M'sila.*

Souk Nathleta Dam which will also be erected at the far hinterland of *wad Boukdoura* in the municipality of *Tadmit (Tizi Ouzou wilaya)* with a storage capacity of 150 million m^3 (Hamadache, 2021). Due to the problem of expropriation, the start of works in it was suspended until late 2011, provided that complete delivery of the project within the year 2015.

Tecnología y ciencias del agua, ISSN 2007-2422,
DOI: 10.24850/j-tyca-15-1-8

This is the previous version of the limited edition company to purchase real estate in a planned program should be mentioned here. And the water projects programmed for it on the hinterland distant from drinking water.

To use the desalinated water

The periods of drought that Algeria has experienced in the last decade have increased the rate of evaporation and the surface waters have become insufficient to meet the needs of the populations of Algiers. The government adopted several projects to rely on unconventional water especially after the advancement of desalination in controlling the price of the local liter. It has planned to establish 15 desalination plants all over the national territory by the year 2015, to produce approximately 2.3 million m / day (Leila, 2021).

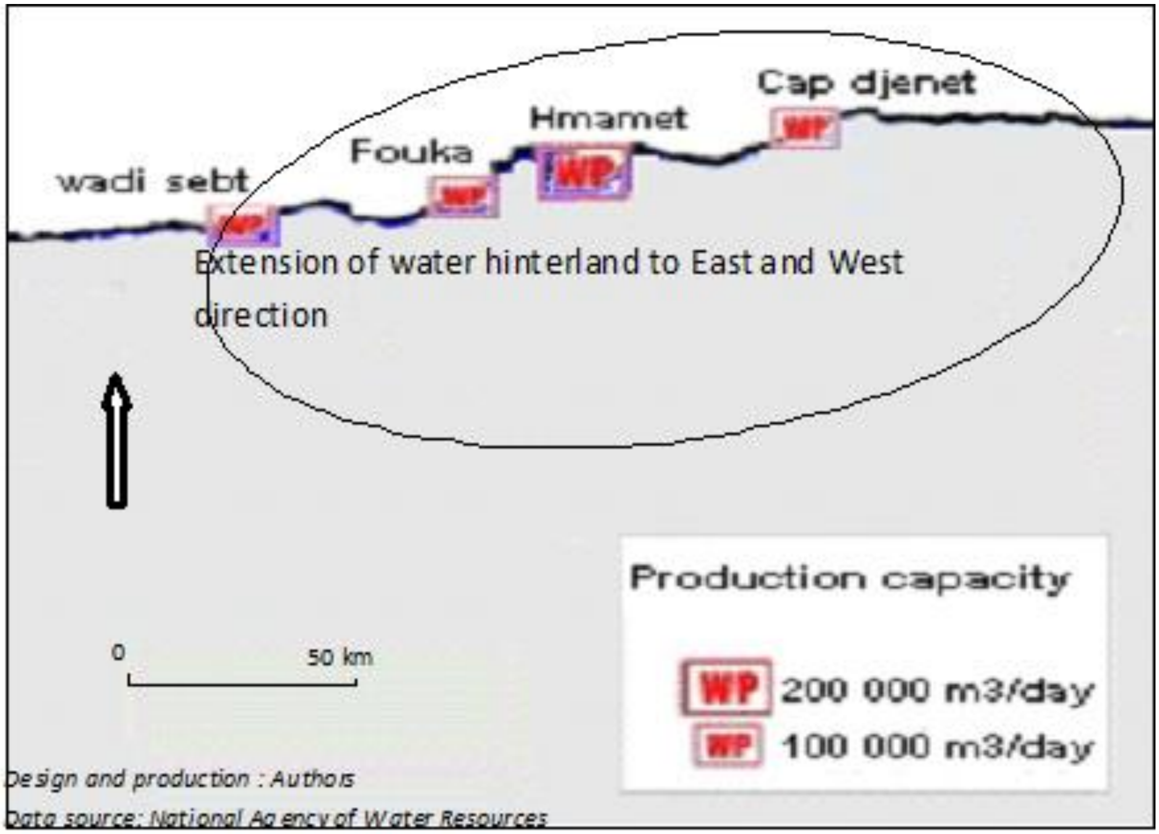

Figure 7: Location of desalination plants in Algiers

Thanks to that, the city of Algiers benefited from a desalination plant in *Hamma* with a production capacity of 200,000 m^3 / day (Leila, 2021). Its lower hinterland also benefited at two stations in *Ras Jannat* and *Zeralda*, its middle hinterland benefited from *Fouka* station (Map 5). After the *Hamma* plant entered the production stage in 2008, the city of Algiers won the battle of water after 11 years of trouble. At that time, it was able to overcome the problem of fluctuation in the distribution with the abundance of water 24h / 24h in the faucets of citizens. After that, the dependence on groundwater wells decreased to 200,000 m^3 / day after it had reached 650,000 m^3/ day in 2006. In 2011, only 175 productive wells remained. This allowed the level of groundwater to rise greatly and renew its reserves in *Mtijah* (Hamadache, 2021). In 2021, a new emergency plan which provides for the strengthening of desalinated water production capacity by building a unit with a capacity of 250,000 m3/d in the capital (Algiers-Ouest), another in Cap Djenat (Algiers - East) with a capacity of 400,000 m3/d. These new projects would make it possible to "reduce by 72% the use of surface water in the capital" according to the director of water resources and hydraulic safety of the wilaya of Algiers.

We observed an extension of the water hinterland towards the east and the west after the commissioning of the desalination plants in 2008. The drinking water supply for Algiers now comes mainly from these stations located along the Algiers coast (Figure 7). This alternative has given satisfactory results, providing a 24-hour service, but with excessively expensive costs compared to the water grounds.

Challenges and opportunities: comparison with Mediterranean examples

Based on a comparative approach of Algiers with the other western south metropolises of the Mediterranean sea, we have contrasted the results with the situation at the scale of this region which suffered under the

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

same climatic conditions. Table 2 shows the water hinterland extension challenges and opportunities for the riparian cities of the western Mediterranean basin.

The comparison between the metropolises of the southern shore of the Mediterranean sea shows similar challenges, particularly between Algiers and Tunis. Rabat has advantages related to precipitation where this city has still not used unconventional water (desalination). The only problem that risks the sustainability of this resource is the overexploitation of water for agricultural purposes. Population growth, rapid urbanization and economic development increase needs of water supply while the resource is rare (Tabaani and al., 2012). However, the hinterland still remains the reservoir to supply the three cities with nuances and fluctuations depending on the periods of drought. Looking ahead to 2100, climatology specialists predict a warming of 2.5 to 4.5°C for the Maghreb countries compared to the temperatures recorded at the end of the 20th century (IPCC-IPCC, 2008). However, the consequences will be harmful on the availability of resources due to the high rate of vaporization and, certainly, the hinterland of water will have more extension towards the most distant zones.

Table 2: Challenges and opportunities of water supply in western south Mediterranean metropolis.

western south Mediterranean cities	challenges	opportunities

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

Algiers (Algeria)*	- The existence of non-renewable but poorly exploited fossil subterranean waters. - Water resources are subject to strong temporal variability both seasonal and interannual. - They are also unequally distributed geographically and above all without correspondence with the location of demand. - Overexploited underground waters which caused the phenomenon of marine intrusion.	- Use of non-conventional water through the use of desalination (15 operational stations with a production of around 2.5 million m3/d). - An important reserve of unexploited fossil waters. - The creation of the national agency for the integrated management of water resources (AGIR) to concretize the reforms undertaken.
Tunis (Tunisia)**	- The existence of non-renewable but poorly exploited fossil subterranean waters. - Water resources are subject to strong temporal variability	- Commitment to the implementation of integrated water resources management by implementing a set of reforms to lay the foundations for optimal, rational and sustainable

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

	both seasonal and interannual. - They are also unequally distributed geographically and above all without correspondence with the location of demand. - Overexploited underground waters which caused the phenomenon of marine intrusion.	management of water resources. - Use of private companies in the upkeep and maintenance of drinking water transfer and supply networks.
Rabat (Morocco)* **	- Phenomenon of marine intrusion aggravated by the overexploitation of groundwater for agricultural purposes. - Intense evaporation which leads to considerable loss of surface water.	- The existence of a large catchment area in the hinterland of Rabat. - Favorable situation where the chain of RIF constitutes a natural barrier pure the climatic disturbances coming from the ocean. - Generalization of the economical irrigation technique (86%).

.BPEH (2013), *.Snoussi.M (2018).

Data source: *.ANRH (2022) unexpected synthesis from this study

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

Tecnología y Ciencias del Agua
OPEN ACCESS
Check for updates

Conclusion

The question remains unanswered by those responsible for this sector: the prospects that these water projects do not meet all the daily water needs of the capital's residents. If the studies had been dropped at the time of the onset of a water crisis within the limits of 2025, the expectations that followed did not support the previous propositions, especially, after the great decline in the pace of demographic and urban growth in the country and in particular, the saturation of space that the capital knows.

At the end of this work, some points that we see are very sensitive in managing the water sector, particularly in Algiers, to save from severe future crises. It's important to invest in the renewal of supply channels in order to reduce the high loss rate. However, investing large sums of money in huge projects without adjusting the problem of wasting nearly half of the water. Besides that, we propose to reconsider the applied pricing, and that is a new one so that their waste will bear it, and we do not equate the economizer with the wasteful.

To avoid technical and management problems in the future. We think that it is necessary to consider a new water policy as part of the urban development services. It is important to develop residential communities

Tecnología y ciencias del agua, ISSN 2007-2422, DOI: 10.24850/j-tyca-15-1-8

close to water sources to attract residents towards it, instead of transporting water long distances to meet their daily needs. There is no doubt that this strategy would not solve the problem in the long term where the complexity and size of the city of Algiers will not be that of today. Therefore, the sustainability of water resources must be taken into account for any reflection related to the planning and management of this rare resource. In addition to being economic that will put our major cities away from severe water crises in the future. Finally, it must be noted that the best and best investment in the water field is to educate citizens in the first place to rationalize consumption. And fighting extravagance using all the available means of employing the media (audio, visual and print), for the same purpose. Also, the best framed in this is the municipalities and local groups thanks to their water police, scientific clubs, neighborhoods societies and different citizens' associations.

We can conclude also the relationship between the spacing of hinterland water and the scarcity of superficial water, especially in the case of the unavailability of non-conventional water (fossil water, desalination) and drought period.

Certainly, we have proposed solutions for the problem of removal from the hinterland of water. Nevertheless, our study has its limits because the analyzes carried out only concern the city of Algiers, excluding the problem of water, which must be dealt with in a broader framework on a regional or even national scale.

This work is based on official data from the national water resources agency, combined with quantitative and qualitative field data. In fact, it could be broadened in perspective for other cities to delimit the zones of probable extension of the hinterlands of waters and the delimitation also of the overlapping areas.

The exploitation of the results of this work by decision-makers or in the context of future research is a great satisfaction for us. The contribution will certainly be positive for the improvement of the quality of life of the populations of Algiers.

References

Abid, O., Benfetta, H. N., & Khaldi, A. (2019). Impact des changements climatiques sur la perte de capacités des barrages situés dans les zones arides et semi-arides. Quelques exemples algériens.

AGEP. (1995). Conférence nationale sur la nouvelle politique de l'eau. Ministère de l'équipement.

BPEH (2013), Note from the Office of Planning and Hydraulic Balances in collaboration with the General Directorate of Rural Engineering and Water Exploitation (DGGREE), the National Company for the Exploitation and Distribution of Water (SONEDE) and the Office National Sanitation (ONAS). URL: https://www.ohchr.org/sites/default/files/Documents/Issues/Water/Handbook/Tunisia.pdf

Benbelkacem, N., & Benallel, H. (2002). Problem of water supply in the wilaya of Algiers. [Engineer's thesis]. university of sciences and technology.

Boudjadja, A., Messahel, M., & Pauc, H. (2003). Ressources hydriques en Algérie du Nord. Revue des sciences de l'eau / Journal of Water Science, 16(3), 285-304. https://doi.org/10.7202/705508ar

Chikher-Saidi, F. (1997). La crise de l'eau à Alger : Une gestion conflictuelle (L'harmattan).

Djaffar, S., & Kettab, A. (2018). La gestion de l'eau en Algérie : Quelles politiques, quelles stratégies, quels avenirs ?

Falcidieno, B., Pienovi,C. et Spagnulo,M., (1992), Descriptive Modeling and Prescriptive Modeling in Spatial Data Handling. *GIS, From Space to Territory : Theories and Methods of Spatio-Temporal Reasoning,* Int. Conf., Pisa, Italy, p

Graillot, D. (1986), *Faisabilité d'un système d'ingénierie pour la réalisation de projets d'aménagement en eau à partir du modèle de simulation : MISE (Modèle Intégré de Gestion de l'Eau)*. Thèse d'Etat, Université de Sciences et Techniques du Languedoc, Montpellier, France, 2 vol., 507 p.

Groupe d'experts Intergouvernemental sur l'Évolution du Climat (GIEC-IPCC), Genève, 2008 – *Bilan 2007 des changements climatiques : synthèse du rapport d'évaluation du Groupe d'experts Intergouvernemental sur l'Évolution du Climat (GIEC)*. Genève : Organisation Mondiale de Météorologie (OMM)/Programme des Nations Unies pour l'Environnement (PNUE), 103 p.

Hamadache, amine. (2021, octobre 26). Crise de l'eau à Alger : Le PDG de SEAAL s'explique. https://www.algerie360.com/crise-de-leau-a-alger-le-pdg-de-seaal-sexplique/

Kadi, A. (1997). Water management in Algeria. Hydrological Sciences Journal, 42(2), 191-197. https://doi.org/10.1080/02626669709492019

Kameche-Ouzidane, D. (2013). Les aqueducs à souterazi de la Régence d’Alger. e-Phaïstos. Revue d’histoire des techniques / Journal of the history of technology, II(2), 73-84. https://doi.org/10.4000/ephaistos.7388

Lanter, D., 1992 : *Intelligent Assistants for Filling Critical Gaps in GIS: A Research Program*. Technical Report 92-4, National Center for Geographic Information and Analysis.

Leila, B. (2021, septembre 18). Crise de l’eau : Une station de dessalement inaugurée à Alger. https://www.algerie360.com/crise-de-leau-une-station-de-dessalement-inauguree-a-alger/

MEAT. (1997). Drinking water supply for greater Algiers [Interministerial Council].

Meddi, H., & Meddi, M. (2009). Variabilité des précipitations annuelles du Nord-Ouest de l’Algérie. Science et changements planétaires / Sécheresse, 20(1), 57-65. https://doi.org/10.1684/sec.2009.0169

Mutin, G. (2000). L’eau dans le monde arabe (Ellipses).

Raymond, A. (2014). La ville arabe, Alep, à l’époque ottomane : (XVIe-XVIIIe siècles). In La ville arabe, Alep, à l’époque ottomane : (XVIe-XVIIIe siècles). Presses de l’Ifpo. http://books.openedition.org/ifpo/505

Remini, B. (2009). Evolution des grandes barrages en régions arides : Quelques exemples algériens. Revue Sécheresse, n°1.

Safar-zitoun, M. (2019). Plan national de sécheresse. Ministère de l'agriculture.

Santos M. (1971), Croissance et urbanisation en Algérie, *Méditerranée*, 2, 8, pp. 731-740. DOI: 10.3406/medit.1971.1403. www.persee.fr/doc/medit_0025-8296_1971_num_2_8_1403

Schilling, J., Freier, K. P., Hertig, E., & Scheffran, J. (2012). Climate change, vulnerability and adaptation in North Africa with focus on Morocco. Agriculture, Ecosystems & Environment, 156, 12-26. https://doi.org/10.1016/j.agee.2012.04.021

Snoussi.M (2018), Contribution to the development of the Integrated Coastal Zone Management Plan of the Rabat-Salé-Kenitra Region, Diagnosis of the coastal zones of the Rabat-Salé-Kenitra region, URL: https://www.swim-h2020.eu/wp-content/uploads/2018/09/2-Snoussi-Diagnostic-RSK-GIZC.pdf

Sutton, K., & Zaimeche, S. (1992). Water resource problems in Algeria. Méditerranée, 76(3), 35-43. https://doi.org/10.3406/medit.1992.2762

Taabni Mohamed and Moulay-Driss El Jihad, "Eau et changement climatique au Maghreb : quelles stratégies d'adaptation ?", *Les Cahiers d'Outre-Mer* [Online], 260 | Octobre-Décembre 2012, Online since 01 October 2015, connection on 24 April 2022. URL: http://journals.openedition.org/com/6718; DOI: https://doi.org/10.4000/com.6718

TOMLIN C.D., 1990: *Geographic Information Systems and Cartographic Modeling*. Prentice Hall, 249 p.

Touazi, M., Pierre Laborde, J., & Bhiry, N. (2004). Modeling rainfall-discharge at a mean inter-yearly scale in northern Algeria. Journal of Hydrology, 296(1), 179-191. https://doi.org/10.1016/j.jhydrol.2004.03.030

Tvedt, T., & Oestigaard, T. (2016). A History of Water: Series III, Volume 3: Water and Food. Bloomsbury Publishing.