

LES SYNTHÈSES

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**Development of large dams in the
Maghreb : results and prospects**

***Water demand management versus
supply policy***

VINCENT Grégoire

February 2017



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International
de l'Eau**

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SYNTHESIS

Development of large dams in the Maghreb:
results and prospects

Water demand management versus supply policy

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Résumé : Face aux défis que représente la raréfaction de la ressource en eau, les pays maghrébins ont donné, et donnent encore, la priorité au développement de grands barrages. Si cette stratégie semble aujourd'hui porter ses fruits, on peut s'interroger sur sa soutenabilité à moyen et long terme. Alors que la gestion de la demande en eau pourrait être une alternative forte, les pouvoirs publics n'ont pas encore investie massivement sur cette option. Il s'avère que la construction de grands ouvrages demeure plus mobilisatrice économiquement et politiquement.

Mots clefs : ressource en eau, infrastructures, grands barrages, réchauffement climatique, raréfaction, gestion de la demande en eau (GDE), politique, Maghreb.

Abstract : For more than forty years Maghreb countries have been facing big water challenges. Morocco, Algeria and Tunisia gave priority to water resource infrastructures as large dams. If this strategy seems to be a success, we can question its sustainability in the middle and long term. Although water demand management could be a strong alternative, authorities still haven't invested enough in this option. In fact, construction of large hydraulic works remains more attractive economically and politically.

Key words: water resource, infrastructures, large dam, global warming, scarcity, water demand management (WDM), policy, Maghreb.

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INTRODUCTION

For all times the control and the allocation of the water have been about power. It is generally said, "water is life". It is also and above all an indispensable resource for agricultural, economic and social development. When there is scarcity of water, as in the surrounds of the Mediterranean, its use in an optimum way is a top requirement. To meet this requirement, Maghreb countries have given priority over recent decades to the development of large dams. If these structures are useful in many respects (reservoir, hydroelectricity, flood protection), it is worth asking whether they are the miracle solution to the current challenges.

The main aim of this synthesis is to take stock of these "barrage" policies. Did they fulfill their original objectives? Are they relevant over the long term? Before answering these questions it will be necessary to clearly identify the reality of the water issues in the Maghreb. We shall then see that the priority given to large dams and large hydraulic works in general is not merely the result of purely technical choices. There is a real enthusiasm from the public authorities that can be explained by political and economic dynamics.. Finally, in the face of the challenges of water, there are alternative solutions to large hydraulic structures. We will see that water demand management (WDM) is a credible alternative but little implemented. Is this a solution for the future? What are the prospects?

This work leads us to ask ourselves a question: in the face of water issues in the Maghreb, is the priority given to large hydraulic structures still relevant?

THE ISSUES OF WATER IN THE MAGHREB: SCARCITY, USES AND PROSPECTS

In order to understand the water issues in the Maghreb, several factors must be taken into account. First, it is crucial to look at climate and demographic dynamics before looking at the economic, agricultural and social aspects.

WATER RESOURCE IN THE MAGHREB: DISTRIBUTION, ACCESS AND RARITY

The Maghreb includes a coastal zone watered. If we except mountain areas such as the Moroccan Atlas, the "water tower" of Morocco, the rest of the Maghreb territory is characterized by an arid or semi-arid climate. It is important to note that average rainfall values per country do not reflect the reality. It exists within each Maghreb country of strong regional inequalities around water resources. When it falls on average 867 mm of water per year in France, there are only 346 in Morocco, 207 in Tunisia and 89 in Algeria (World Bank, 2014). So we understand the situation: little water, unevenly distributed between territories. Out of this this rainwater that falls each year 88% on average is evapotranspired. This means that of the 357 km³ of water that falls each year, only 44 km³ is potentially usable. This is called the renewable resource. Of these 44 km³ only 75% are mobilizable and 62% manageable. Thus, on average, Maghreb people have 340 m³ / year / inhab. Behind this figure are disparities. In Algeria, the ratio is more around 290 m³ / year / inhabitant (Taabni and El Jihad, 2012). As a reminder, the World Health Organization recommends a minimum ratio of 1000 m³ / year / inhabitant. Given that Maghreb countries are well below this threshold, they are in a situation of "water stress".

It is important to note that we are talking about renewable water. For example, Tunisia provides 40% of its water needs through underground deep-water (fossil water) (FAO, 2015a) and Algeria more than 7% through desalination (FAO, 2015b). However, it seems hazardous to think that a structural problem, the water deficit, can be solved by short-term and unsustainable solutions. Thus, in the context of our topic, it seems appropriate to focus on mobilization and efficient use of renewable resource.

WATER AS A STRATEGIC ISSUE: USES AND CONSUMPTION

The agricultural sector is the most water-demanding sector. In Morocco, Algeria and Tunisia, agricultural sector represents respectively 88%, 59% and 80% of the water consumption (FAO, 2015c, FAO, 2015b, FAO, 2015a). Agriculture, and because of agricultural expansion, there is a very high demand for water. Drinking water supply accounts for 7% (Morocco) to 37% (Algeria) of water withdrawals (FAO, 2015c, FAO, 2015b).

Behind these figures there are some dynamics. There is an increase in consumption. In Algeria, for example, 8.4 billion cubic meters of water were taken in 2012 compared with only 2 billion in 1970 (FAO, 2012). Similar trends are observed for Morocco and Tunisia. How can we understand this dynamic? The demographic factor seems obvious. An upward trend in population increases the pressure on the resource. This is combined with other phenomena such as changes in lifestyles or urbanization. The extension of irrigated land is perhaps the most important factor. Ambitious agricultural policies were launched in the 1970s, especially in Morocco with the objective of a "million hectares irrigated". Finally, economic and industrial expansion often requires water. These include the explosion of the tourism sector in Morocco and Tunisia during the 1990s.

As we can see, different phenomena explain the pressure on the water resource. When water is abundant, it appears natural that it meets all needs. When it becomes scarce it becomes an eminently strategic resource. In 2012 about 10, 500 km³ were collected in Morocco. The demand was close to 14,500 km³ of water. (FAO, 2015c) The shortage that year was real. There is then a very great potential for conflicts of use. The challenge is therefore, on the one hand, to avoid these conflicting situations by satisfying demand and, on the other hand, to manage shortages harmoniously.

CLIMATE CHANGE: TOWARDS THE CRISIS?

According to the Intergovernmental Panel on Climate Change (IPCC), the Maghreb will face in 2100 an increase in temperatures between 2.5 and 4 ° C and a drop in rainfall of 10 to 30% (Taabni and El Jihad, 2012). Recurrence and intensity of extreme events, such as droughts, are expected to increase. So we will see a continued decline in available water resources in the Maghreb. This is a daunting challenge for public authorities that are already facing shortages.

Outlooks are therefore far from optimistic. Inequalities in access to water are expected to increase. We can imagine a questioning of the modes of production, especially in the agricultural sector. Desalination offers opportunities for creating freshwater resources but remains very expensive in terms of energy. We will see in the future if this production will make it possible to fill the water deficit.

THE POLICIES OF LARGE DAMS IN THE MAGHREB: SOLUTION OR a HEADLONG RUSH?

To cope with the challenges of water Maghreb countries have led from the years 70-80 ambitious policies of construction of large dams. We will see how these policies have been put in place. We will then take stock.

LARGE DAMS IN THE MAGHREB, A HISTORY MARKED BY POLITICAL VOLUNTARISM

The history of the large dams in the Maghreb began under French colonization. The colonial power erected the first dams in the Algerian mountains from the 1870s (Perennes, 1992). It was really in the 1920s that the 'barragist' policy was driven by colonial power in Algeria and Morocco and then in the 1950s in Tunisia. This development mainly serves two purposes: to develop agriculture and to supply drinking water to the large urban centers where settlers are concentrated (El Jihad, 2001).

At independence, the national authorities took over these development policies. With the impulse of King Hassan II Morocco opened a period of strong development of large dams in the 1960s. This policy was guided by the objective of the "one million hectares irrigated". In Algeria, the State launched major hydraulic development projects in the 1980s. In ten years, fifteen dams were built in the country. Finally, in Tunisia, the 1970s marked the start of the large dams policy with the ambition of making significant transfers between the north and the south of the country (Pérennès, 1992). These policies are emblematic of the concept of "Etat aménageur". These policies will still be based in part on foreign companies and contribute, at first, to a loss of know-how in local water management.

OBJECTIVES TO RESULTS: WHICH BALANCE SHEET?

There are four main objectives for the development of large dams: meeting agricultural needs, securing drinking water supply, hydroelectric production and flood protection.

First, let us look at the agricultural objectives. The million hectares irrigated was (use the simple past, if you were a historian and the subject was quintessentially historic, ok. I would argue it is not.) achieved in Morocco in the late 80s. Agricultural areas have been increasing since the achievement of this objective. Today irrigated areas account for about 1.5 million hectares, of which about 690,000 are due to large-scale irrigation (FAO, 2013a). Algeria is in a slightly different situation. Irrigated areas have increased from 282 000 hectares in 1986 to more than 1.2 million hectares in 2014. Large dams feed only 20% of this land (FAO, 2015d). Furthermore, only 40% of equipped surfaces were irrigated due to the water shortage and the poor condition of the networks. Finally, large dams have also contributed to agricultural development in Tunisia. The surface of land equipped for irrigation had tripled between 1976 and 2012 (FAO, 2013b). Large dams feed 30% of this irrigated land (FAO, 2015a). Dams have therefore played an important role in agricultural development. It is nevertheless to consider that other factors contribute to this development such as irrigation methods, the use of boreholes and small and medium hydraulic structures.

Securing drinking water supply is another objective of the development of large dams. As in the colonial period, large dams, coupled with infrastructure for the transfer of water, set a goal of securing the supply of drinking water. Without accurate data we can note a few emblematic examples of this success. In Morocco, projects that rely on the construction of dams have made it possible to secure supply for large urban centers such as Casablanca or Marrakech. In the same idea, in Algeria we can retain the symbol of the transition to running water 24h / 24 in cities such as Algiers and Oran which was not the case before the dam construction. In Tunisia too, dams and transfer infrastructures play a predominant role in the supply of drinking water. The theme of drinking water supply in itself is a subject that could be interesting to deal with more thoroughly. Nevertheless, the interest of large dams in the field is noteworthy.

If hydropower adds value to the water resource, it is not in itself a water management tool. In other words, a dam will not be better for meeting water users' needs if it generates electricity. On the contrary, the periods of power production, and therefore release of water downstream,

may be inadequate with the needs of the users. However, hydroelectric generation is a well-established objective of the development of large dams. It is an interesting alternative energy because of its flexibility and its low carbon impact. This also makes it possible to make the high costs of constructing dams over the long term. Hydroelectric production, which accounted for 66% of total energy production in 1971 in Morocco and 26% in Algeria in 1973, fell in 2013 to around 10% in Morocco and 0.5% in Algeria. In Tunisia this share is negligible since the late 1970s. So there is in Morocco that hydroelectric generation truly has weight nationally, although it is constantly decreasing. It should be noted that this energy production is highly dependent on rainfall. Thus, between 2010 and 2012, hydroelectric production in Morocco declined by more than 50% (Observ'ER, 2013). If hydropower seems insignificant compared with other energy sources and other functions of large dams, we nevertheless retain its importance in terms of peak production.

Without dwelling on it, we note finally the usefulness of large dams in the fight against floods. This function is far from negligible, especially in Morocco where floods can be as sudden as they are violent. We can also think of the potential recreational activities that a dam can eventually generate.

LARGE DAMS, A SUSTAINABLE MODEL IN THE MAGHRÉBIN CONTEXT?

We have seen the development of large dams has filled the main dedicated objectives. But at what cost? Siltation, evaporation, decreasing rainfall, deterioration of structures, and environmental and social impacts raise the question of the sustainability of the model of large dams.

The enthusiasm for the dams in the Maghreb was accompanied by a certain lack of knowledge of the areas where dams were established and a deficit of integrated management. A greater sedimentation than expected led to a high siltation of the artificial lakes. Silting accounts for about a quarter of the total volume of Tunisian and Algerian works. In Morocco this represents about 10% of the volumes (Benblidia et al., 2001). In Tunisia, for example, the annual siltation rate is between 0.5 and 1%. It is estimated that by 2030 siltation could account for 43% of the total volume in Tunisia (Remini et al., 2009). There are many ways to fight against this phenomenon, but it can be expensive (elevation or reconstruction of dams) or difficult to achieve with flushing (given the chronic water shortage in the reservoirs). The most common solution is dredging. This solution, like others, does not offer sustainable prospects. The best solution, little practiced, is to manage watersheds upstream of dams, in order to avoid erosion (reforestation, vegetation, pastoral management, conservation agriculture). This issue is put in perspective with the aging of structures. Worn out, the old works are also more expensive in terms of maintenance. The impact of leaks is far from negligible.

The problem of evaporation is real. It is estimated that of the 13 billion m³ stored in Morocco, one billion is lost each year by evaporation. A study carried out between 1992 and 2002 on 39 Algerian dams shows that annually 6.5% of the total volume is lost by evaporation (Remini, 2005). It even happens that Sahel evaporation is greater than the water consumption. Without going into more detail we realize that evaporation is a major issue. This deficit could be accentuated in the coming years due to global warming. This is also where one of the recurring problems of large dams is the fill rate. The recurrence of droughts and the trend the decline in rainfall raises the question of the sustainability of the dam model based on a predictable and relatively fixed filling rate. In Morocco, for example, the filling rate can be very irregular from one year to another and from one region to another. Let us take the situation as of November 25th, 2016. The filling rate at the national level was and still is 43%. One year before this rate was 66%. The Hassan II dam was filled to 77% in 2015 against only 16% in November 2016 (Government of the Kingdom of Morocco, 2017). Again a more detailed analysis, in time and space, would better reflect these realities. Nevertheless, the filling of dams today, and

tomorrow, poses the question of the sustainability of the dam model to meet the challenges of water supply.

Finally, the development of large dams raises the question of social and environmental impact. From an environmental point of view, the disruption of ecological continuity can undoubtedly be a problem. In the case of the Maghreb, it is mainly problems linked to the sediment blockages that no longer reach the sea (beach sands, fishing). Social impacts can also be real. What first comes to mind is the displacement of populations as in Morocco for the construction of the El Hachef dam (Franssen et al., 1999). The other, more diffuse and lasting impacts are mistakenly neglected. The presence of a large dam can induce changes in agricultural practices. If farmers positively perceive access to irrigation, they must be able to adapt and endure a financial cost. Moreover, the construction of a large dam implies an allocation of water resources. This allocation can create or reinforce inequalities in access to the resource. Without efficient watershed management, a minority upstream may monopolize the resource. The approach of political ecology carried out by researcher François Molle goes further. A dam construction would not create a new resource but just lead to a reallocation of resources (Molle, 2012). For example, the water that is retained is the water that will not fill the water table downstream. The dam would only solve a problem to create another one elsewhere.

Finally, the financial sustainability of dams also raises questions. Water from large Moroccan dams costs between 2.54 and 5.2 dirham / m³ (between 0.22 and 0.52 euros). But this cost is often not the cost paid by consumers. Thus, even with a system of equalization of costs, the State is forced to subsidize agricultural water (Tenesson and Rojat, 2003). If the economic impact of dams often proves to be positive because of the many services provided, the financial profitability of the distribution of water from the dams raises more questions.

UNDERSTANDING THE ENTHUSIASM OF PUBLIC AUTHORITIES FOR LARGE HYDRAULIC WORKS

There is undoubtedly an enthusiasm of the public authorities in the Maghreb for the great hydraulic works. Morocco, Algeria and Tunisia continue to invest in large dams and transfer structures. In this we see a real willingness to focus on water supply. We will try to understand, beyond the technical aspects, this craze of today and yesterday's governments for these large hydraulic structures.

BETWEEN CONCENTRATION AND CENTRALIZATION OF POWER, THE DECISION FROM THE TOP

The Maghreb states have different cultures and different modes of functioning. Nevertheless, they all have one common point, except for Tunisia since 2011, of being governed by authoritarian regimes. These states also have the characteristic of being historically very centralized. They inherited and adopted the concept of a planning state set up by the colonial power (Mikaïl, 2006). In Morocco, the state was centralized around the royal power and the royal power was consolidated around this centralization. In Algeria the central bureaucracy has considerable weight in the state apparatus. There is also a persistence of the single party and powerful central unofficial powers. Finally in Tunisia, it emerges from years Bourguiba and Ben Ali strong centralization of power. Decentralization was extremely limited.

Water governance has followed this centralized model. First there is the existence of a "hydraulic bureaucracy" (Tanouti and Molle, 2013), mainly in the ministries, which has been carrying out development projects for decades. Basin agencies have been established since the 1990s. Their financial and decision-making power is limited, and the central government retains control over large-scale water projects. The case of Morocco is interesting. The Wali,

the equivalent of the “préfet” in France, still has considerable importance in planning policies (Tanouti and Molle, 2013).

We must therefore understand that, the Maghreb decision-making process is vertical. Large projects are often, but not always, the result of "top-down" decisions.

POLITICS AND MAJOR HYDRAULIC WORKS: BETWEEN LEGITIMATION OF POWER AND POLITICAL OPPORTUNITY

The German historian Karl August Wittfogel is considered the thinker of "hydraulic despotism". For this specialist in Asia, the control of the great hydraulics by the State responds as much to a necessity as to an opportunity for the latter (Ruf, 2011). First of all it is a necessity because the installation of large hydraulic structures needs strong investments and large scale planning. It is also an opportunity because the control of the hydraulic systems gives the governor a great power of social control. It is this social control that would lead the political regimes to their despotic nature. Wittfogel formulated this theory by relying on Asia. It is possible to make connections with the situation in the Maghreb due to the authoritarian nature of power and the importance of large hydraulic systems in this area of the world where water is scarce.

The powers in place in the Maghreb did not hesitate to base part of their legitimacy on the construction and control of these large hydraulic structures (Molle et al., 2009). Large dams are symbols of progress and development. Major building policies become mythical mobilizing the nation (Benhadi, 1976). The political authorities are fully involved in the promotion of these works. The inaugurations are the occasion to stage the action of power and to bring the nation together around the project. It is interesting to note that in Morocco many dams are the supports of national emblems. First of all the motto "Allah, Alwatan, Almalik" ("god, nation, king") often accompanied by the Moroccan six-pointed star.

Social control, ?if is not a will?, can be considered as a consequence of the development of large hydraulic structures. Farmers who irrigate with water from large dams are in a situation of recognition and / or dependence on the rulers. On this point a study on the large irrigated perimeters of the Euphrates in Syria is remarkable (Foy and Keilo, 2016). The authors show that in 2011 there were very few anti-Assad demonstrations compared to the rest of the country. These conclusions lead us to reflect on the opportunities for social control provided by large-scale hydraulic projects.

“PRO-DAMS” ADMINISTRATIONS?

Following the national independence administrations have kept the French dichotomy between rural engineering and civil engineering (Pérennès 1992). Moreover, associations or syndicates of irrigators have lost influence compared to regional and national offices. The hydraulic installations were designed by administrations completely controlled by engineers. Water users, and in particular farmers, have not been sufficiently involved in the development of large-scale hydraulic works.

Therefore, one may wonder if the popularity of large dams is not made in part of an internal paradigm for national administrations. For nearly 60 years, civil engineers have been involved in the construction of large dams. This has allowed them to gain legitimacy and develop national know-how. It is interesting to note that in Morocco, between 1991 and 2005, national companies carried out 82% of the civil works of the dams. Before 1980, all these works were managed exclusively by foreign companies (El Ghomari, 2015). This know-how is now being exported successfully onto the African continent.

ALTERNATIVE TO LARGE DAMS: WHAT PLACE FOR MANAGING WATER DEMAND (WDM)?

It thus appears that in the Maghreb the water policies go through the development of large hydraulic works including large dams. Nevertheless, there are alternatives to these policies. Water demand management is one. How is it thought out and implemented in the Maghreb? What role could the GDE take in the challenges facing the Maghreb countries?

WDM IN THE MAGHREB: FROM THE EMERGENCE OF A CONCEPT TO THE IMPLEMENTATION OF PUBLIC POLICIES

First, an observation. In the Maghreb between 55 and 65% of agricultural water is "lost" in the networks. The same is true for 50 to 60% of the water in the large transfer channels. Water "waste" can account for nearly 47% of the resource. Overall, city networks have yields that are close to 50%. It is estimated that up to 25% of demand could be met through the efficient implementation of WDM (Taabni and El Jihad, 2012).

WDM is a multidimensional approach that aims to save water resources. This approach can be applied sectorally. In the agricultural sector, WDM requires the implementation of more water-efficient irrigation schemes, more efficient management of this irrigation and an agronomic approach (sowing of species more resistant to drought, for example) and By improving the economic value of water. In the domestic, tourism and industrial sectors, WDM can be divided into various actions. We can think of improving network performance through more efficient management. One can also think of policies aimed at domestic water savings. Finally, wastewater reuse can be promoted. In the economic sector, WDM is mainly tied to the tariff approach. This involves setting tariffs, quotas or subsidies encouraging users to save water (Plan Bleu and GWP, 2012).

In the 90s and 2000 are held, particularly under the influence of donors, many international meetings on the GDE which Maghreb countries are taking part. A first workshop on the subject took place in Fréjus in 1997 followed by two more in Italy and Spain in 2002 and 2007. Furthermore, in 1996, the Mediterranean Commission for Sustainable Development (MCSD) was created, on a proposal from Tunisia. The 16th meeting of the commission was hosted by Morocco in 2015. The Maghreb is fully involved in the emergence of this concept. Thus, during the period, the Maghreb countries put in place their first policies oriented towards WDM.

Morocco, Algeria and Tunisia put in place pricing policies at the turn of the 2000s. Watershed agencies have been established. In Tunisia and Morocco, groups of collective interests for irrigation are created. Efforts, particularly remarkable in Morocco, are focused on conversion to localized irrigation. Finally, several large cities are calling on multinationals to take charge of the management of their water services or to support municipal boards. Thus, WDM policies are implemented in parallel with the emergence of the concept in the Mediterranean.

OPPORTUNITIES AND LIMITATIONS OF WDM POLICIES

There are undoubtedly successes in the implementation of WDM in the Maghreb. It is appropriate here to return to these successes. In Algeria, WDM efforts have made it possible to secure drinking water supplies. Thanks to efforts on leakage in the networks and on the rationalization of distribution, resulting in particular from leasing contracts with multinationals, large cities, including Algiers, have switched to a 24-hour distribution. Tunisia 30% of treated

water is reused (Taabni and Jihad El, 2012). It is a remarkable rate. In Morocco, localized irrigation has developed strongly over the past 20 years. Overall consumption in urban areas has declined in the Maghreb, in particular through pricing policies. Each Maghreb country appears to be "ahead" of a particular aspect of WDM.

However, enormous gains in water are still achievable, as well as much better economic valorization. The principles of WDM have not been fully implemented by countries. Due, in particular, to the necessarily intersectoral nature of WDM. In institutional landscapes very sectorialised, it is difficult to carry out cross-sectoral policies. It also appears that if the political will is displayed, the financial and human capacities dedicated to WDM actions seem to be lacking compared to those mobilized for major works.

By way of illustration, Morocco is pursuing an ambitious policy of constructing dams with a target of 50 new dams by 2030. In 2012, approximately 2.2 billion dirhams (220 million euros) were allocated by the Moroccan state to the construction of dams and 200 million (20 million euros) to their maintenance (LaVieEco, 2012). The cost of the M'Dez dam, the largest currently under construction, is estimated at 1.5 billion dirhams (150 million euros). While it is difficult to make more significant figures, these data allow us to realize the financial effort that represents an ambitious dam construction. It would be interesting to compare these financial flows with those dedicated to WDM policies. However, the multidimensional and intersectoral character of WDM makes such an estimate extremely difficult.

Moreover, the principles of WDM can be diverted from their primary goals, saving water. In Morocco, for example, the transition to localized irrigation was most often accompanied by an extension of agricultural land. In cases like this the impact on the reduction of water demand is almost zero. We can also think, from what we have seen in the preceding sections that policy makers prefer the use of construction of major works, perhaps to the detriment of WDM policies.

WHAT PLACE FOR WDM IN THE CHALLENGES OF TOMORROW?

Given the scarcity of water resources, the use of WDM policies appears to be relevant. Saving water potentials are still important. Nevertheless, these water savings would be in vain if they were accompanied by an increase in demand induced by an unlimited extension of demanding water activities. The case of irrigation in Morocco, which we mentioned earlier, is characteristic of this type of phenomenon. While WDM may be relevant, it remains politically unattractive. The results of such policies are more diffuse and longer to be felt than those aimed at supply. Obviously, supply and demand policies are complementary. Nevertheless, the public authorities prioritize their action on certain levels.

Excluding the construction of large dams, solutions to increase water supply have emerged in recent years. The first is the exploitation of the Saharan fossil aquifer by Tunisia and Algeria. If questions arise as to the sustainability of such a long-term solution, in the short term this would solve the problems associated with the scarcity of the resource. The other solution is desalination. The development of desalination plants is a major trend of recent years in the Maghreb but also throughout the world. The fall in production costs has allowed a true democratization of this technology. Desalination nevertheless poses major questions of economic and environmental sustainability.

CONCLUSION

The policy of building large dams in the Maghreb in recent decades has undoubtedly allowed agricultural development and safe drinking water supply in urban centers. Trends in rainfall,

siltation of structures, evaporation, and saturation of sites and rising costs of construction of new infrastructure (best sites being exploited first) are all factors that can lead us to think that we are at the end of these barrage policies. Large dams, and more generally the great works, yet remain politically and economically mobilizers. In the Maghreb context, the management of water demand seems to be adapted to the challenges posed by the scarcity of the resource. If it is suitable, it would be a mistake to regard it as a miracle solution. However, the government has not yet implemented policy. Indeed, a passage to WDM requires a true "cultural revolution" from the role of the State and the responsibility of users. This would involve moving from a purely technical approach to a more economic approach (water valorisation). However, WDM policies are difficult to conceive and implement because of their sometimes ambiguous, even contradictory, effects with the stated objectives (see localized irrigation in Morocco).

Regional cooperation on WDM could be relevant. As each country is more advanced on a particular aspect of WDM, one can imagine that sharing experiences would be mutually beneficial. Moreover, a better account of national policies and social dynamics would allow donors to better understand the expectations of policy makers. A better valorization of WDM to the population could, for example, encourage policy makers to focus more on these solutions.

With WDM or large dams, the scarcity of water is accentuated in the Maghreb decade after decade. Managing the shortage is likely to be the major challenge facing the Maghreb rulers. Priorities should be given, economic and social choices made. How?
To be continued.

BIBLIOGRAPHY

Banque Mondiale, 2014. *Hauteur moyenne des précipitations (mm par an)*. Disponible sur Internet : <http://donnees.banquemondiale.org/indicateur/AG.LND.PRCP.MM.>, [Consulté le 30/01/2017]

Benblidia M., Salem A. et Demmak A., 2001. Extraction des sédiments dans les retenues. *La Houille Blanche*, (6-7), pp 76-78

Benhadi A., 1976. La politique Marocaine des barrages. *Annuaire de l'Afrique du Nord*, 13, pp. 275-293

El Ghomari K., 2015. *Politique des barrages au Maroc*. Saint-Martin d'Hères, CFBR, 62 p. [Diffusé le 29/01/2015]

El Jihad M.D., 2001. L'eau de la montagne et le pouvoir étatique au Maroc : entre le passé et le présent. *Annales de Géographie*, 110 (622), pp. 665-67

FAO, 2012. *Base de données d'AQUASTAT database Base de données – Résultats*. Disponible sur Internet : <http://urlz.fr/4JfJ>, [Consulté le 30/01/2017]

FAO, 2013a. *Base de données d'AQUASTAT database Base de données – Résultats*. Disponible sur Internet : <http://urlz.fr/4Jog>, [Consulté le 30/01/2017]

FAO, 2013b. *Base de données d'AQUASTAT database Base de données – Résultats*. Disponible sur Internet : <http://urlz.fr/4Jok>, [Consulté le 30/01/2017]

FAO, 2015a. *AQUASTAT - Système d'information de la FAO sur l'eau et l'agriculture*. Disponible sur Internet : http://www.fao.org/nr/water/aquastat/countries_regions/tun/indexfra.stm, [Consulté le 30/01/2017]

FAO, 2015b. *AQUASTAT - Système d'information de la FAO sur l'eau et l'agriculture*. Disponible sur Internet : http://www.fao.org/nr/water/aquastat/countries_regions/DZA/indexfra.stm, [Consulté le 30/01/2017]

FAO, 2015c. *AQUASTAT - Système d'information de la FAO sur l'eau et l'agriculture*. Disponible sur Internet : http://www.fao.org/nr/water/aquastat/countries_regions/mar/indexfra.stm, [Consulté le 15/01/2017]

FAO, 2015d. *Base de données d'AQUASTAT database Base de données – Résultats*. Disponible sur Internet : <http://urlz.fr/4Joi>, [Consulté le 30/01/2017]

Foy R.O. et Keilo J., 2016. *La grande hydraulique au service du pouvoir : l'exemple du Projet de l'Euphrate en Syrie (1966-2013)*. Disponible sur Internet : <http://cybergeog.revues.org/27505> [Consulté le 31/01/2017]

LaVieEco, 2012. *Maroc : 130 barrages et 14 autres en cours de construction*. Disponible sur Internet : <http://lavieeco.com/news/economie/maroc-130-barrages-et-14-autres-en-cours-de-construction-21256.html> [Consulté le 17/02/2017]

Mikaïl B., 2006. Une prise de conscience perpétuellement inachevée ?. *Confluences Méditerranée*. 3 (58), pp. 39-50

Molle F., Molinga, P., Wester P., 2009. Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power. *Water alternatives*, 2 (3), pp. 328-349

Molle F., 2012. La gestion de l'eau et les apports d'une approche par la *political ecology*. Chap. 10. In : Gautier D. et Benjamin T.A., *Environnement, discours et pouvoir*. Versailles, Editions Quæ, pp. 219-238. Update Sciences & Technologies

Observ'ER, 2013. La production d'électricité d'origine dans le monde : détails par région et par pays. Chap. 3. In : *Quinzaine inventaire : la production d'électricité d'origine renouvelable dans le monde*. Paris, Observ'ER, pp. 277-279

Pérennès J.J., 1992. Un aspect de la question hydraulique au Maghreb : la politique des barrages. *Egypte/Monde Arabe*, 1 (10), pp. 37-50

Plan Bleu et Global Water Partnership, 2012. *La gestion de la demande en eau : L'expérience méditerranéenne*. Stockholm, Global Water Partnership, 84 p. Analyse technique

Remini B., 2005, L'évaporation des lacs de barrages dans les régions arides et semi arides: exemples algériens. *Larhyss Journal*. (4), pp. 81-89

Remini B., Leduc C. et Hallouche W., 2009. Evolution des grands barrages en régions arides : quelques exemples algériens. *Science et changements planétaires /Sécheresse*. 20 (1), pp. 96-103

Ruf T., 2011. Le façonnage des institutions d'irrigation au XXe siècle, selon les principes d'Elinor Ostrom, est-il encore pertinent en 2010 ?. *Natures Sciences Sociétés*, 4 (19), pp. 395-404

Seddik S., 2015. *Les ressources en eau de la Tunisie*. Tunis, Ministère de l'Agriculture des Ressources Hydrauliques et de la Pêche, 51 p.

Taabni M. et El Jihad D., 2012. Eau et changement climatique au Maghreb : quelles stratégies d'adaptation ?. *Les Cahiers d'Outre-Mer*, (260), pp. 493-518

Tanouti O. et Molle F., 2013. Réappropriations de l'eau dans les bassins versants surexploités. Le cas du bassin du Tensift (Maroc). *Etudes rurales*. 2 (192), pp. 79-96

Tenneson M. et Rojat D., 2003. La tarification de l'eau au Maroc : comment servir différentes causes ?. *Afrique contemporaine*, 1 (205), pp. 151-169

OTHER USEFUL REFERENCES

Association Sportive de Pêche et de la Protection de l'Environnement de Bejâd, 2012. *Carte des barrages du Maroc et leur implantation*. Disponible sur Internet : <http://asppebejaad.fr.gd/Barrages-du-Maroc.htm> [Consulté le 17/02/2017]

Ministère Délégué auprès du Ministre de l'Énergie, des Mines, de l'Eau et de l'Environnement, chargé de l'Eau du Royaume du Maroc, 2017. *Situation journalière des principaux grands barrages*. Disponible sur Internet : <http://www.water.gov.ma/patrimoine/barrages/situation-journaliere-des-principaux-grands-barrages/>

APPENDICES

APPENDICE 1 : IMPLEMENTATION OF DAMS BY COUNTRY

Map of Algerian large dams in 2009 (Remini et al., 2009)

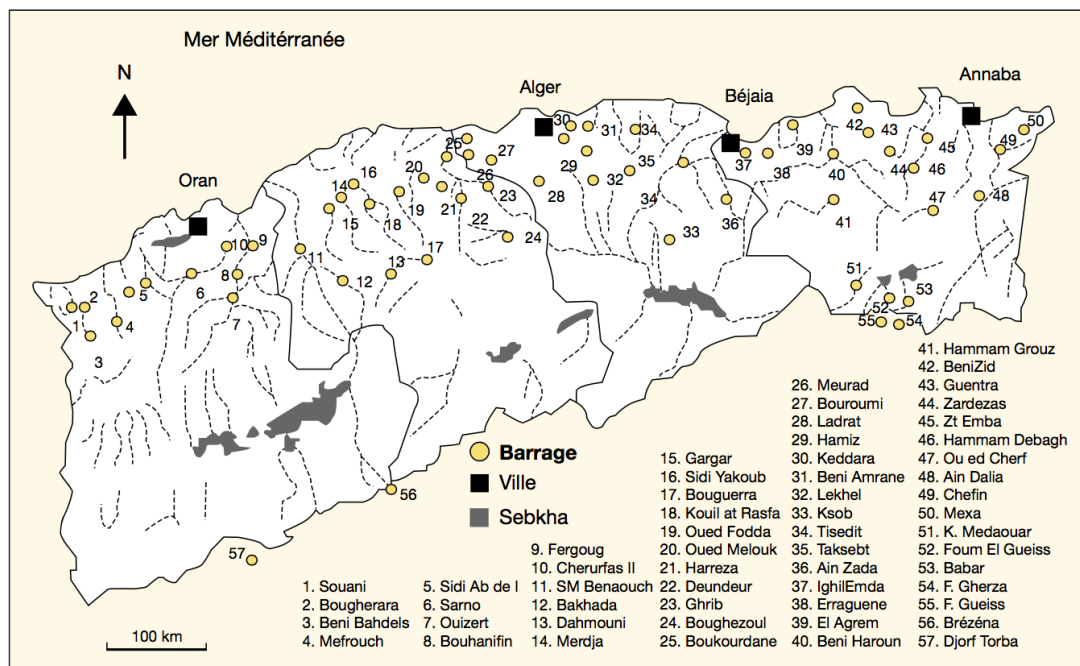
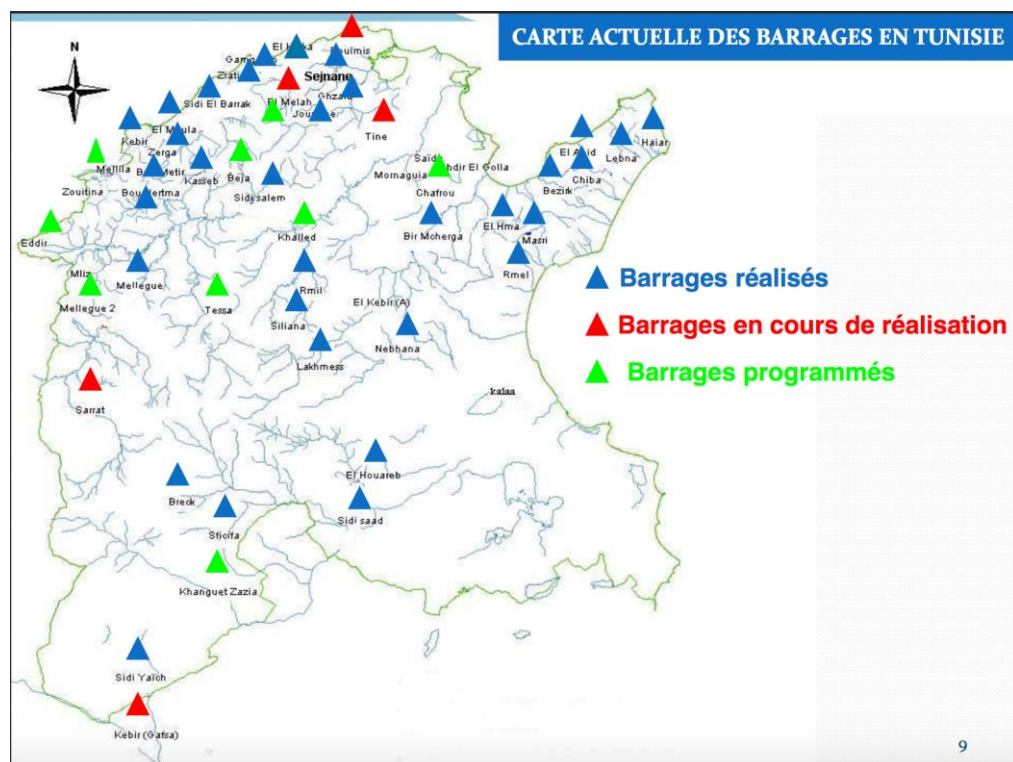
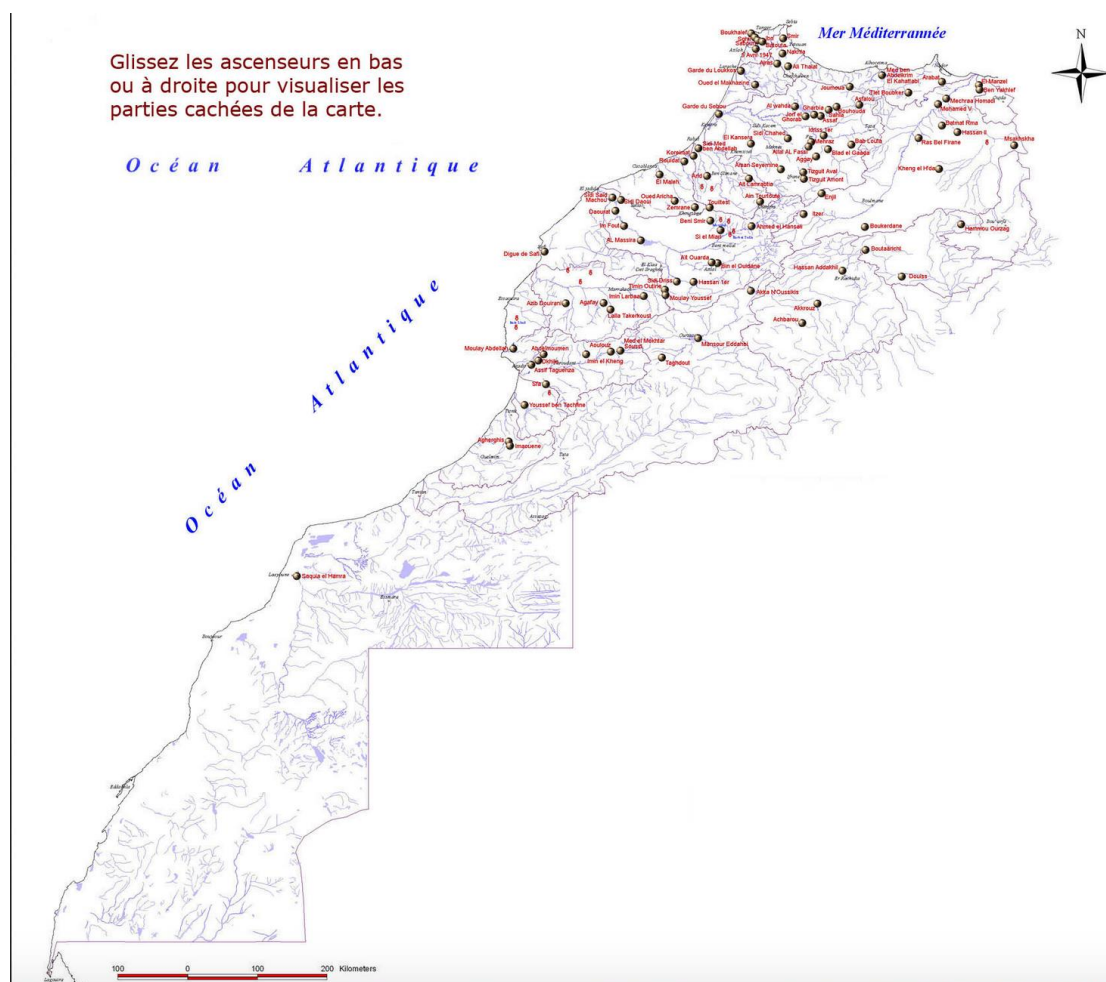


Figure 2. Répartition des barrages en exploitation dans le Nord algérien.

Map of Tunisian large dams in 2015 (Seddik, 2015)

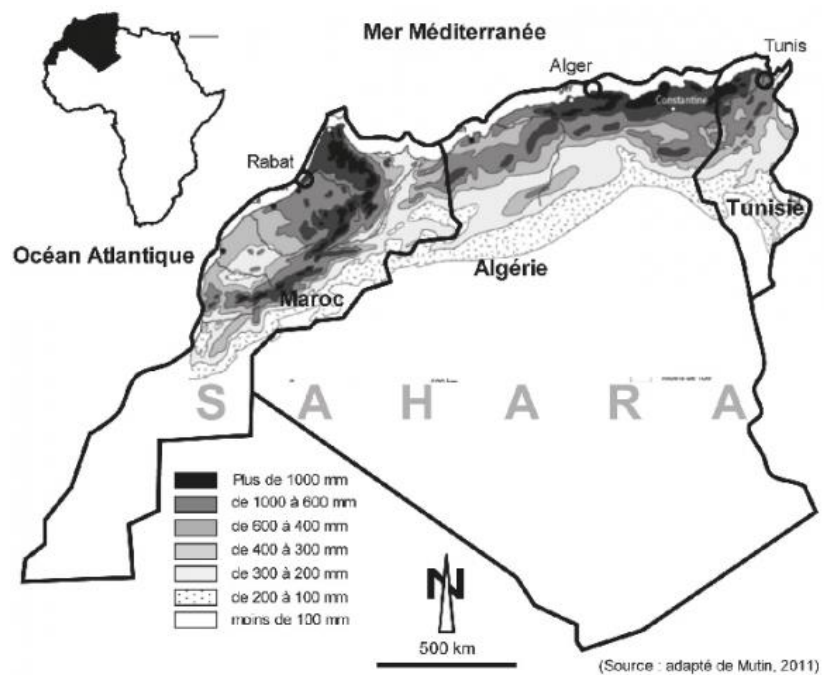


Map of Moroccan large dams in 2012 (ASPPEB, 2012)



APPENDICE 2 : MAP OF ANNUAL RAINFALL IN 2012

(Taabni et El Jihad, 2012)



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