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# Water policy in Algeria: limits of supply model and perspectives of water demand management (WDM)

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**ABSTRACT**

In a context combined with demand increase and climate change phenomenon, water scarcity will intensify hence the necessity of efficient water policy. This paper aims to propose an analysis advocating a transition from the supply-side management of water resources to demand-side management (water demand management) for Algeria. Despite many efforts towards building infrastructure, hydraulic engineering and the process of institutional reforms in Algeria from 1999 to 2019, water management continues to focus on upstream water mobilization without downstream valorization. Water policy in Algeria suffers from several major deficiencies: (1) constraints in the absorptive capacity of capital expenditure; (2) low level of water efficiency in drinking water and in agricultural water; (3) under-utilization of capacities in hydraulic equipment; (4) siltation of dams and reservoirs; and, (5) multidimensional dependence on foreign economies. This nation-wide policy is characterized by a lack of institutional coordination and many multi-level governance gaps. This paper demonstrates that water policy in Algeria is in the transitional phase. The present challenge is to reduce the duration of this transition to achieve sustainable development goals (SDGs) in particular SDG 6.

*Keywords:* Algeria; Water; Water scarcity; Water policy; Supply-side management; Water demand management (WDM)

## 1. Introduction

Countries are currently confronted with the major challenges related to water resources [1]. Water policy plays a key role in water resources mobilization and the valorization process. Climatic aridity and issues related to climate change have made Algeria a vulnerable territory where water scarcity arises with greater acuity. The water stress index for Algeria is poor with a water availability ratio of 411 $m^3$/cap/y and ranks Algeria in absolute water scarcity [2–5]. Forecasts estimate a ratio of 320 and 300 $m^3$/cap/y in 2030 and 2050 respectively [5,6]. Furthermore, the water resources vulnerability index reached 87.1% in 2012[1] characterizing severe water scarcity [4,5,7,8]. The multidimensional indicator of water scarcity, notably the water poverty index (WPI)[2] [9] has improved from a score of 49.7 [10] to a present score of 79.37 [3,11]. The improvement of WPI for Algeria does not come from the physical availability of water resources but rather from other variables (e.g., public investments, progress in adaptive capacity). Water scarcity has made Algeria

[1]The index was calculated by taking the gross withdrawals. We are not referring to net withdrawals or consumptive water use. Therefore, the return flows that are likely reused by downstream users and that infiltrate partly in groundwater are not considered.

[2]The WPI was forged by [9] and [10]. It is a composite index of five elements: resource, use, access, capacity, and environment. The final result varies from 0 to 100. A low index indicates a high degree of water scarcity.

among the countries where food self-sufficiency is far from possible because the minimum water endowment for food self-sufficiency is 912 $m^3$/cap/y, nearly twice the capacity seen in present-day Algeria [12]. Therefore, water scarcity in Algeria indeed exists.

In addition to the natural water scarcity, water policy in Algeria is marked by management policy excessively oriented towards increasing water supply to the detriment of developing better uses of the available resources. Thus, the current Algerian hydraulic model is at the crossroads with many deficiencies resulting from path dependency of institutions and non-economic considerations [13–15]. These weaknesses require a passage from supply-side management characterized as a hard path approach [16,17] or a first-order focus [18] to a water demand management (WDM) (demand-side management) or a soft path approach [16,17] or a second-order focus [18]. The WDM requires two essential stages: (1) end-use efficiency of water ("*more crops per drop*" or "*more uses per drop*") and (2) allocative efficiency so that the water is intended for the most productive uses ("*more value per drop*" or "*more jobs per drop*") [16,17,19–21]. These WDM principles constitute the basis for increasing water productivity and specialization resulting in comparative advantages in water endowments [22–24]. This last stage of WDM explains the importance of virtual water as a coping strategy for water scarcity [19,24,25].

WDM aims to reduce water use and to create better valorization of resources already mobilized. The policy advocated by proponents of the WDM approach is the introduction of economic incentives (e.g., water pricing and water market) or legal and coercive instruments (e.g., non-market actions such as restrictions, quotas, licenses) [16,17,26–30]. Communication, awareness and education policy aspects should not be ignored as they represent the cornerstone on which a policy of real water culture is based and profitable intangible investments. These factors are designed by their supporters as a catalyst for the emergence of social capital and an intellectual capital capable of influencing user behaviors such as a change in water demand. They are also a source of social learning [31–35] an institutional learning, multi-level governance; and, effective adaptive governance [36–38]. Even though WDM makes it possible to defer expensive investments, to delay the gap between water supply and water demand, and to begin natural resource reconstruction (NRR)[3], it is not the panacea or a miracle solution to water scarcity problem.

In the early developmental stages of water policy in an arid country like Algeria, big infrastructure construction and supply-side management (called also hydraulic mission) is strongly recommended [18,39]. However, the depletion of exploitable water resources jeopardizes the sustainability of these infrastructures, calling for new management processes, especially WDM policies and water conservation strategies. This paper highlights the weaknesses of the water policies of Algeria and demonstrates that a transition to demand-side management (WDM) is necessary. It emphasizes the importance of the implementation of new approaches to water governance in the Algerian context. This paper is structured as follows: a presentation of the methodological approach, the context, and the study area; a detailed analysis of the weaknesses of water policy in Algeria; in parallel to the analysis of the weaknesses, the discussion of different research results will be carried out.

## 2. Methods and data

### *2.1. Study area*

Algeria is the largest country in Africa (2,381,741 $km^2$) and is characterized by a high degree of natural diversity. From the coastal zone of the Tellian Atlas with a Mediterranean climate (4% of the territory), Algeria characterized by a mountainous/steppe zone with highs plateaus (9% of the country) dominated by a continental climate and transitioning to the vast Saharan regions (87% of the national territory). In addition to these great disparities in the natural environment, similar disparities of population density exist. According to the National Statistical Office (NSO), Algeria had 43 million inhabitants on January 01, 2019[4]. The coastal zone concentrates more than 63% of the total population while the highs plateaus regions contain 26% of the total population of the country and only 11% of the population inhabits the Saharan regions. This concentration of the population in the coastal zone produces a significant pressure on national water resources; moreover, the majority of groundwater is over-exploited becoming a source of intersectoral conflicts requiring difficult arbitrage with a high social cost.

### *2.2. Methodological approaches and data*

In spite of great water projects construction, inter-basin water transfers, and law promulgation aimed at water protection and exploitation of the existing water potential in Algeria, water policy continues to focus on increasing water mobilization without downstream valorization. This paper delineates some of the major bottlenecks and deficiencies of water policy in Algeria. Indeed, the limits of management in the water sector imposes a transition to WDM and valorization of water resources through the application of universally accepted and globally applied approaches. Our study highlights, in detail, the weaknesses surrounding (1) the low absorptive capacity of the capital expenditure allocated to the water sector; (2) water efficiency in the water drinking distribution systems and in the irrigation system; (3) under-utilization of capacities in hydraulic equipment principally in seawater desalination plants (SDP), in wastewater treatment plants (WWTPs) and in other infrastructures; (4) the siltation of dams and reservoirs; and, (5) the multidimensional dependence on foreign economies as the technological dependence on equipment and engineering. Water policy in Algeria is characterized by a lack

[3]Natural resource reconstruction (NRR) [40] exists when a country (or a society) introduces WDM measures effectively and efficiently in intersectoral water reallocation. NRR calls for the strict application of the water allocation policy and differs from a water withdrawal corresponding to the natural sustainability threshold [40,41]. Once the threshold has reached a decoupling of population increase and water withdrawals should be observed.

[4]http://www.ons.dz/spip.php?rubrique34 accessed on December 20, 2019.

of institutional coordination and many multi-level governance gaps. Our study briefly describes other limits of these policies, such as the failures in the water pricing system and the under-utilization of the equipped area.

This study is realized in a context with favorable evolutions of the water sector indicators in Algeria. The period from 1999 to 2019 is considered as an important step to overcome the water crisis and the economic water scarcity that has existed for decades. This period is marked by a series of institutional reforms promoting principles of Integrated Water Resource Management (IWRM) like: (1) the promulgation of the Law No. 05-12 relating to water; (2) the creation of the Ministry of Water Resources (MWR) in 1999 which is called Ministry of the Water Resources and Environment after the reform in 2015 and the return of the MWR on May 2017; (3) the creation of the Integrated Water Resources Management Agency in 2011 and the installation of this agency in December 2014; and, (4) the establishment of River Basin Committees (RBC) (*comitésdubassinhydrographique*) and the National Advisory Council on Water Resources (NACWR) (*Conseil national consultatif des ressourceseneau*). In this work, our methodological approach is both quantitative, as in the case of the investment expenditure (funding) in the water sector for the period 1990–2018, drinking and agricultural water efficiency, etc. and qualitative, mainly in the study of multi-variable dependence on foreign economies and the lack of institutional coordination and multi-level governance gaps. It's multidimensional and consists of four components:

- The analysis of research related to water such as the paradigm of WDM and NRR [16–20,40–43]; the water management paradigms [39]; the social learning approach applied to the water resources governance [31–35]; multi-level and adaptive governance of water [36–38]; and, the indicators approach of water scarcity [2,3,9–12] and we make allusion to works of Dinar and Saleth [13–15] relating to the institutional reforms in water sectors.
- A thorough and critical reading of reports of institutions responsible for the implementation of water policy principally the study for updating the National Water Plan (NWP) (*Plan national de l'eau*) [44–47] and consultation of studies related to water resources realized by international institutions (World Bank) [48]. As it stands, we focused on technical reports studying the Algerian hydraulic paradigm and its worldwide limits evoked in theory.
- Water data and information in Algeria from the central directorates of the MWR, National Agency for Dams and Transfers, National Office of Irrigation and Drainage (NOID), and Algerian Water Company (AWC). We would like to point out that access to the data was difficult for us. Besides, some data were unreliable, the objective was then to focus on the most credible sources of information. They were then treated according to their nature and reliability since the water sector in Algeria suffers from an information gap [37,38]. These data were aggregated from wilayas[5] or water sub-sectors (drinking water, sanitation, dams, irrigation, general studies, etc.) as the case may be. Concerning information related to investment in the water sector and the calculation of Gross Domestic Product (GDP) shares invested in the water sector between 1990 and 2018, an aggregation of data from the water sub-sectors and analysis at the constant price was carried out. The database for the period 1990 to 2018 contains all the investment programs as presented in the MWR annual plans for the capital budget (capital expenditure). Indeed, we used the capital expenditure canvas (excel files) between 1990 and 2003 and all the reports on the implementation of the annual plan between 2004 and 2018. The expenditures incurred were reported by the MWR in the current Algerian dinar (DA). Therefore, for reasons of comparability and relevance of the analysis, we have deflated these amounts against the Gross National Expenditure Deflator whose reference year is 1999 according to Medianu and Whalley and Kherbache and Oukaci approach [49,50]. The deflator is derived from the World Bank database.

  As for other data related to drinking and agricultural water efficiency, the analysis was based on the Blue Plan [51] method after the data have been aggregated at the national level. These were communicated to us by wilayas in the case of AWC and by large-scale irrigated schemes (LIS) in the case of NOID. Finally, some weaknesses in water policy in Algeria were deduced from the interviews and the comparison of the actual functioning of the infrastructure with nominal capacities, such as the under-utilization of the SDP and the under-irrigation of the areas equipped in the LIS.

- This study was also facilitated by discussions and interviews with executive staff in some water institutions responsible for the implementation of water policy in Algeria, and as well as through visits to projects realized or ongoing which are seen as the reference of the water supply model (hydraulic mission) in Algeria. Thus, after the first two steps of our methodology, we have identified the main actors in the implementation of water policy in Algeria. Then, we conducted 23 semi-structured interviews between February 2015 and March 2019 with senior officials in the water sector, including some MWR central directors and water agencies directors. The findings were implicitly incorporated into the analysis of the results because the majority of directors refused to be explicitly mentioned in the work and the preferred anonymity. Even so, we have included some summarized passages in the parts of the results while avoiding mentioning the interviewees.

  This part of the methodological approach was used to see the awareness of those responsible vis-a-vis weaknesses of the hydraulic model in Algeria. It allowed us to illustrate the last two results of our study, namely dependence on foreign economies (technological dependence, dependence on foreign engineering "know-how" and food dependence) and the lack of institutional coordination and multi-level governance gaps.

[5]The wilaya is an administrative division in Algeria (Algeria is divided into 48 wilayas).

## 3. Results and discussion

### *3.1. Patent funding effort: origin of the supply model and low absorptive capacity*

Algeria has successfully met the challenge of water mobilization during the analyzed period (1999–2018). This period is considered as an exit of the country from economic water scarcity[6] which prevailed before 1999 when the investments in the water sector were less than 0.8% of GDP for the period 1990–1998 (Fig. 1). Following an upward trend in oil prices, the substantial financial windfall enabled the Algerian authorities to launch a voluntarist policy of public investment in the water sector. Adaptive capacity to water scarcity has improved since 1999 allowing Algeria to a conjuncture of structurally-induced relative water abundance with a first-order resource scarcity (water resources) and a second-order resource abundance (adaptive capacity) [5,19,20,42,43]. Indeed, the overall amount authorized as part of public investment programs was valued at US$36.1 billion[7] (~ 2878 billion DA) between 2000 and 2018. The investment realized for the same period was roughly US$22.7 billion (~ 1821.7 billion DA); thus, the average absorption rate[8] is estimated at 62.88%. For the first years of the analyzed period, the absorption rates were substantial and sometimes the water sector over-consumed the capital expenditure (budget). This is the case for the financial year 2002 with an absorption rate of 110%, 2004 (114.74%) and 2005 (106%), but over the years and from 2006 the rate follows a downward trend to reach 42.11% in 2011 and 38.69% in 2012 before its increasing to 58.55 % in 2015 and 81.44 % in 2018.

According to water managers and policymakers, this weakness in the sector's absorption capacity between 2006 and 2016 (Fig. 1) is explained by the following factors [46]:

- The slowness of public procurement (contract) procedures without granting requests for relief from these procedures.
- The complexity of expropriation procedures without the rigorous application of regulatory texts.
- The insufficient budget allocated to some projects due to weak project studies and cost analysis methods.
- The circumstances of stopping project realization due to bad weather, climatic conditions (high temperatures in the case of transfer of In Salah-Tamanrasset) and disruptions in the supply of raw materials, although major projects have priority under the law.
- Intra-sectoral and intersectoral interferences (particularly with the transport, energy and housing sectors) between projects despite the existence of coordination and consultation bodies responsible for dealing with such discrepancies.
- The low absorption capacity is also due to the lack of qualifications of the companies in charge of the project realization. The political positioning of some corporate groups supported by influential managers who prevent the termination of contracts in the event of non-advancement of the project and therefore the inability to absorb the investment funds allocated. These groups are called by a senior water sector executive "*hydraulic political lobbies*".

This investment effort and the institutional reforms between 1999 and 2019 were the sources of water indicators improvement in Algeria and the improvement of the WPI [3,5,11]. Therefore, Algeria was able to achieve the targets of the millennium development goals (MDGs)[9] related to the drinking water services and access in sanitation services before the UN fixed the deadline of 2015 [49]. As a result of this achievement, Algeria ensured access to safe drinking water to the majority of the population with a connection rate of 98% in 2016, compared to 78% in 1999. Similarly, Algeria achieved the sanitation facilities target with a connection rate to the sewerage network of 90% in 2015 compared to 35% in 1970 [5]. Furthermore, the infrastructures for water mobilization (e.g., the number of dams) increased considerably over 50 years from 13 operational dams in 1962 to 78 dams in 2018 of 124 dams by 2030. The number of WWTPs increased from 12 active stations in 1999 to 177 in 2016. The equipped area reached 225,304 hectares (ha) in 2017 while it was 156,000 ha in 1999. The water sector in Algeria has benefited from considerable GDP shares (Fig. 1).

The GDP share allowed for water funding (equipment funding or public investment) followed the same pattern as the increase in Algeria GDP. In effect, the payment appropriations (budget) have fluctuated between 0.84% and 1.60% of GDP for the period 1999 to 2005. But since 2006, an expansion of the water sector budget reached a threshold of 6.39% of GDP in 2009. This period marks the beginning of the construction of some major investment projects (e.g., transfers and dams). This upward trend in investment marks the beginning of a restrictive policy starting in 2009. In 2012, the rate stagnates around 3.61% of GDP by the rate decrease to 1.64 % in 2016 and 1.57 in 2018. In fact, in terms of investment in the water sector, Algeria is almost at the same level as in the 1990s and early 2000s in 2018. However, even if the GDP allocated to water investment was important, Algeria still faced difficulties in absorptive capacity. In the first years of the period analyzed, the share of GDP allocated to water investments approximated the share of GDP absorbed, but as soon as the water sector marked a certain expansion the two variables diverged and the share of GDP targeted for water investment tended to fall. For example, in 2009, the GDP allocated is valued at 6.39% but the GDP absorbed is estimated at 3.64%, while in 2012, 3.61% was

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[6]Economic water scarcity occurs when a country has significant water resources, but it lacks the financial, technical and even human resources to exploit them [4,5,7,8].

[7]In constant 1999 US dollars.

[8]The absorption rate is defined as the ratio of payment appropriation (budget or capital expenditure) to real expenditures. It is also called the consumption rate of credits.

[9]In the MDGs, the target 7.C of Goal 7: "ensure environmental sustainability" stipulates; "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation".

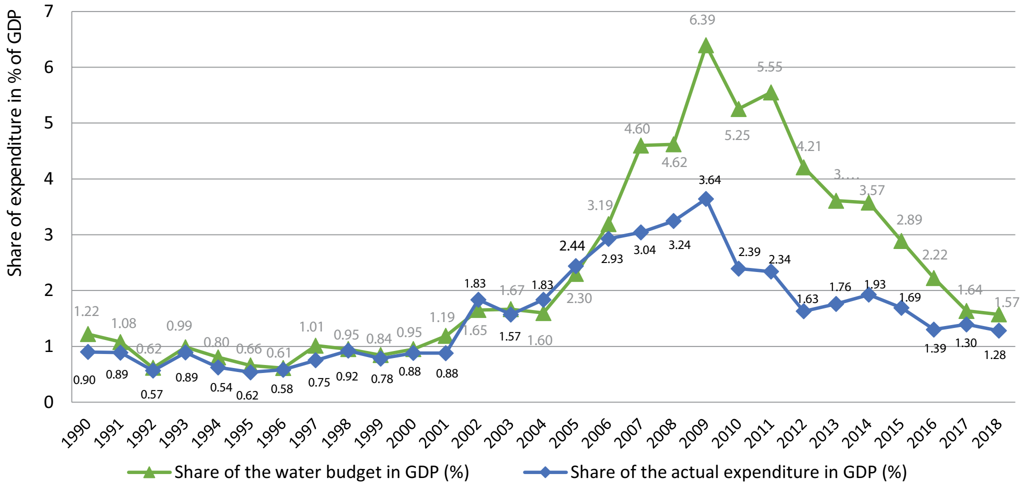



Fig. 1. Evolution of water expenditure shares in GDP.
*Source*: Compiled by the author, MWR and NSO data.

allocated; the sector was able to absorb only 1.76%. In 2008, despite the stagnation of the allocated share (4.6% in 2007 and 4.62% in 2008), the portion of GDP absorbed increased from 3.04% to 3.24%. This phenomenon was also observed for 2003 and 2004. However, since 2009, the decrease in allocated shares went hand in hand with the absorbed shares to reach only 1.28% in 2018. An overview of the Organization for Economic Co-operation and Development (OECD) country's investments in the water sector shows an average of 0.75% of GDP as the share allocated to the water sector. China spends more than 1.5% of its GDP on water investment, Turkey approximately 1.9%, Mexico 1.89%, and India 0.71%[10]. Algeria consecrates a consistent and adequate level of GDP to water investment, but the effectiveness of these efforts is unsatisfactory and has been oriented in supply-side management with many proven limits.

### *3.2. Water use efficiency: a high rate of leakage with a heavy economic cost for water companies*[11]

The beginning of 1990 was marked by the emergence of the fourth water management paradigm which was notably an economic paradigm [39][12]. Henceforth, water is recognized as an economic resource (good) [52]. This approach is fundamental to the implementation of IWRM which facilitates the WDM. The introduction of WDM measures results in two steps; namely, end-use efficiency and allocative efficiency [20,23,42]. Allocative efficiency is oriented towards the realization of more value per drop, more jobs per drop or doing better things with the water. This step of WDM is technically feasible, but it is characterized by extreme political and social complexity [20,21,23,42,43]. In Algeria, the end-use efficiency of water is low. The leakages, whether physical or commercial, represent financial losses for water service providers. The NOID and the AWC record extremely high losses which limited their scope for water-saving. Those lost volumes constitute a substantial potential to be valorized.

#### *3.2.1. Drinking water efficiency: the case of AWC*

The problem of water leakage in the drinking water distribution networks has been systematically criticized as the weak point of water management in Algeria. This indicator was and will remain a sign of water resources management. The low rate of return (i.e., efficiency ratio) of water distribution networks is due to a series of causes relatively easy to overcome (e.g., dilapidated distribution systems, weaknesses in the installation of water metering and some "free-rider" behaviors like illicit water pipe connections and water theft). Discussions with AWC staff have revealed that this company has, sometimes, not even water network plans especially those that were inherited from the colonial period. This makes the task of leak detection complex and arduous.

The differences (gaps) between the drinking water production, its distribution, and its billing are considerable.

[10]It is difficult to conclude by a comparative analysis between countries because other factors affect the GDP share allocated to the water sector (e.g., GDP value, the number of populations, the surface of the country concerned). The development level of the developing countries which are feeling the most intense investment needs in the water sector; however, there GDP level remains low.

[11]It is useful to remember that improving water efficiency through the adoption of water-saving technologies can produce the opposite effect "Jevons paradox or rebound effect" on the resources at the river basin scale which exacerbate the deficit and water scarcity. In this subsection we analyze the losses in relation to water compagnies (AWC and NOID) only, disregarding the impact on downstream users and the consequences on the basins.

[12]Noted that Tony Allan distinguished five water management paradigms. The first two paradigms were the pre-modern paradigm (1850–1900) with limited technical and organizational capacities and the hydraulic mission (1900–1980) which is part of industrial modernity. The remaining paradigms are part of reflexive modernity (i.e., the green paradigm "inspired by environmental awareness of the green movement"; the economic paradigm; and, the political and institutional paradigm "which is based on the notion that water allocation and management are political processes") [39].

The water conveyance efficiency which measures the physical losses between the place of water mobilization and the volume put in the water distribution networks were valued at 86.88% in 2011 and 86.91% in 2012, representing a rate of leakage of 13.12% and 13.09%, respectively (Table 1). These losses mark disparities in the regions managed by the AWC. In 2011, while losses were estimated to be between 5% and 12% for certain areas (i.e., Algiers, Oran, Batna, Béchar, Chlef, Tizi Ouzou), they were 23.37% for the Annaba area, 21.1% for the Sétif area, 30.75% for the Souk Ahras area and 24.15% for the Constantine area. Water distribution efficiency which measures the water volumes distributed but not billed to the users showed considerable commercial losses. These latter were estimated at 52.26% in 2011 and 52.4% in 2012 corresponding to leakages of 589.622 million ($Mm^3$) and 615.674 $Mm^3$, respectively (Table 1). Consequently, the commercial losses for AWC increased between 2011 and 2012. This situation can be explained by the transfer of responsibility from certain municipalities to the AWC[13]. Moreover, global water efficiency is low for these two exercises. It is only 41.48% (2011) and 41.37% (2012) so a global loss (physical losses and commercial losses) of 58.52% (2011) and 58.63% (2012) which means that an important amount of water produced does not count and never benefits the AWC in a cost recovery perspective. These efficiencies are low compared to the performances of the water distribution networks in Tunisia where the global efficiency was around 78% in 2007. But what can be praised is that in this country the water distribution efficiency was 83.5% (on 417 $Mm^3$ of water distributed, 348 $Mm^3$was billed) [51].

Besides, it is important to note that these leakage volumes (commercial and physical) also constitute financial losses to the water service providers. For this reason, the absorption of water losses could be a source of income that can be used to cover maintenance costs and operating costs. The volume of water lost for AWC was around 792.674 $Mm^3$ in 2012, so based on the average national tariff of 0.23 US$/$m^3$, the financial losses are valued at 182.32 million US$ (the average tariff of $m^3$ is estimated at 18 DA with total financial losses of 14.27 billion DA. The conversion was based on an average exchange rate of US$ 77.806 DA/US$ in 2012). The objective of the absorption of water losses is an indicator for the implementation of WDM measures [53]. The rated leakage should in no case exceed 20% [54]. Thus, WDM would enable Algeria to a water-saving of 792 $Mm^3$/y which presents 25.5% of drinking water demand, an estimated 3.1 billion $m^3$ ($Bm^3$) in 2012.

### 3.2.2. *Agricultural water efficiency: the case of NOID*

Leakages in water systems are not limited to drinking water distribution networks but extend to be more striking in agricultural water distribution systems. In principle, agricultural water efficiency concerns both the two aspects of irrigation specifically the LIS that are under the responsibility of NOID and the small and medium hydraulics (SMH) managed individually by farmers. For this latter, it is difficult, and even impossible, to measure the proportion of losses given the problems of data availability on irrigation methods and the volumes of water withdrawal actually from groundwater via water wells. For the LIS managed by NOID, the Office communicate the allocated water quotas by the MWR, the volumes of water released (or pumped) from the dams (V1), those put at the head of the network (V2) and the volumes distributed upstream the plots to be irrigated (V3). These data allow the calculation of the different efficiencies and the volumes of physical losses (Table 2).

The agricultural water efficiencies in Algeria are lower than in drinking water efficiency. The global efficiency is estimated at 72.86% in 2012 and it marked improvement compared with the year 2008, where it recorded 68.6%. In other words, the rate of leakage in irrigation systems managed by NOID exceeds 27.1%. This rate hides very remarkable regional disparities. Between the hydrographic regions, the Sahara has the most favorable efficiency with a loss rate of 3.5% (Table 2). This fact is due to the use of pumping from groundwater, which allows low losses, but it should also be noted that in the Sahara the plot efficiency would be drastically modest given the important needs of plants and the phenomenon of evaporation. The region of Oranie is close to the national average with a global efficiency of 71.06%. In contrast, the regions of Chéliff, Algérois, and Constantinois are characterized by a rate leakage of 34.7%, 31.7%, and 35.4% respectively. The most efficient perimeters

Table 1
Drinking water efficiency in Algerian Water Company (AWC)

| Volumes (years) | Produced water volume $V_1$ ($m^3$/y) | Distributed water volume $V_2$ ($m^3$/y) | Billing water volume $V_3$ ($m^3$/y) | Water conveyance efficiency = $V_2/V_1$ (%) | Water distribution efficiency = $V_3/V_2$ (%) | Global water efficiency = $V_3/V_1$ (%)[a] |
|---|---|---|---|---|---|---|
| 2011 | 1,298,705,000 | 1,128,307,000 | 538,685,000 | 86.88 | 47.74 | 41.48 |
| 2012 | 1,352,000,000 | 1,175,000,000 | 559,326,000 | 86.91 | 47.6 | 41.37 |

[a]Calculate the rate of return and global water efficiency, we used the [51] approach.
*Source*: Compiled by the author, AWC data.

[13]The management of drinking water service in Algeria is assured by the AWC and the municipalities but in the long run the management will be totally assured by the AWC because the majority of the municipality providing their services are confronted with the financial constraint which results in consumers reluctance to pay a failing service hence a poor quality of service. In 2013, it has been forecast a transfer of prerogatives to the AWC from 174 municipalities. For big cities, they are managed as part of management contracts with internationally renowned companies.

Table 2
Agricultural water efficiency for LIS managed by NOID in 2012

| Volumes Agricultural areas | Volumes of water released (or pumped) $V_1$ ($Mm^3$) | Volumes at the head of the network $V_2$ ($Mm^3$) | Volumes distributed $V_3$ ($Mm^3$) | Conveyance efficiency $V_2/V_1$ ($Mm^3$) | Distribution efficiency $V_3/V_2$ ($Mm^3$) | Global efficiency $V_3/V_1$ ($Mm^3$) |
|---|---|---|---|---|---|---|
| Oranie | 21.8 | 18.31 | 15.49 | 83.99 | 84.60 | 71.06 |
| Chéliff | 217.53 | 160.43 | 142.13 | 73.75 | 88.59 | 65.34 |
| Algérois | 66.69 | 61.3 | 45.57 | 91.92 | 74.34 | 68.33 |
| Constantinois | 82.2 | 65.89 | 53.08 | 80.16 | 80.56 | 64.57 |
| Sahara | 112.22 | 111.79 | 108.33 | 99.62 | 96.90 | 96.53 |
| Totals | 500.44 | 417.72 | 364.6 | 83.47 | 87.28 | 72.86 |

*Source*: Compiled by the author, NOID data.

are Dahmouni (85.1%), Bougara (89.1%), Hamiz (83.3%), Zet Emda (85%), Jijel %), Oued Righ I and II (97%) and El Outaya (92.2%).

The weakness of global efficiency in the LIS managed by the NOID and the importance of these losses is due to various factors. The most notable of which are management failures, lack of maintenance in agricultural water distribution systems, weakness of the utilization rate of water-efficient irrigation techniques, the pricing systems that do not provide incentives for saving water which justifies the high level of water wastage, illicit stitching in water pipe and water theft by farmers, institutional accountability gap, problems of organization, valorization, and choices of irrigated crops. Taking charge of these problems would be the source of water-saving and a WDM pillar [19,21,42,43,53,54]. That being said, the efforts of recent years have boosted relatively the water efficiency notably with the increase of maintenance expenditures from 2.57 US$/ha in 2006 to 12.85 US$/ha in 2012. Also, a Blue Plan study carried out in 2009 on the water uses efficiency highlighted differences and the evolution of water efficiency between 1995 and 2005 in the Mediterranean area. This study situated Algeria in the countries where performance in terms of agricultural water efficiency remains the most mediocre alongside other Southern Mediterranean countries such as Greece, Italy, Albania, Bosnia and Herzegovina, Croatia, Lebanon, Slovenia, Syria, the Palestinian Territories, and Turkey with a global efficiency that varies between 40% and 60% and far away from the leading countries, notably Cyprus and Israel with a global efficiency of 84% and 81% respectively. Dinar and Saleth [15] found that if efficiency improves by 10%, the irrigated area would increase by 2 million ha in Pakistan and 14 million ha in India.

### 3.3. Under-utilization of capacities in hydraulic equipment installed

#### 3.3.1. Under-utilization of the equipped area managed by NOID

A numerous capital-intensive project was built in Algeria, but without the users are feeling their real impacts on water services improvements. This is due to the absolute primacy given to investment policy rather than to exploitation of infrastructures [55] had noticed this logic of equipment to equip regardless of whether or not they serve any purpose even when it comes to the context of water scarcity. According to the director of NOID: *"Algeria invests a considerable amount in the water sector; however, the country has few projects in operation, which explains the defective condition of infrastructures and hence the low level of productivity in the irrigation sub-sector"*. The case of the LIS presents an example of this problem of under-utilization. In 2015, the total equipped area was 260,590 ha whereas the irrigated area did not exceed 86,171 ha, representing only 33.07%. The inadequacy of irrigated areas is attributed directly to the low water quotas allocated by the Water Resources Assessment and allocation Committee (WRAAC) of the MWR, but also to the financial situation of the perimeters, in particular, the irrigated perimeters of wilayas, which are almost-bankrupt. In 2012, the NOID recorded an estimated fiscal deficit of 15.1 million US$ (1174.68 million DA). According to the MWR data consulted in 2019, this deficit has reached 6.52 million US$[14] (779.56 million DA) in the second half of 2016 only. Therefore, the objective of the Algerian government to expand the equipped area with large hydraulics constitutes an inconceivable aberration among others insofar as it is intolerable to construct new perimeters and to equip other areas while those that already exist have been abandoned or are in a lamentable situation. The [45] reported that some 24,300 ha of the equipped area is lost and 57,100 ha which should be rehabilitated in 2008.

Prioritizing the satisfaction of domestic water, needs is an objective of water policy in Algeria (Law No. 05-12 relating to water). Thus, the process of water allocation to LIS does not follow the principle of the second stage of WDM, in particular, the allocative efficiency [16,18,21,23,42]. It is indeed an application of a legal text that favors the satisfaction of the needs of cities and the watering of livestock before affecting water to irrigation and industry according to the following prioritization scheme: population-agriculture-industry (noted that after the independence

[14] It should be noted that the deficit has increased relatively in DA, the decrease in US$ is due to the devaluation of DA. The DA has lost about 48% of its value compared to the dollar since 2014. In December 2019, US$1 was exchanged for 119.57 DZD compared to 80.58 DZD in 2014, a loss of more than 39 DZD: https://www.bank-of-algeria.dz/html/marcheint2.htm accessed on December 19, 2019.

in 1962, the prioritization scheme was: Agriculture-industry-population. However, with the industrialization program, agricultural development projects, population growth and the dynamics of urbanization; the allocation pattern changes again as follows: Industry-agriculture-population [55]. In fact, the needs "*quotas solicited*" are announced by the farmers to the responsible of the irrigated perimeters before the irrigation campaign from 1 April to 31 December, then consolidated by NOID staffs before that the WRAAC met to make the necessary arbitrage based on resource availability (especially in the dams) and all needs for drinking water and industrial water. Thus, the Committee allocates "*initial quotas*" and with the course of the agricultural season, it may complement, at the request of farmers and depending on water availability, these quantities by "*additional quotas*". The total of these two quotas constitutes what is called "*allocated quotas*".

### 3.3.2. Under-utilization of capacities in SDP

The strategic focus of seawater desalination exists in the priorities of water allocation. It is one of the objectives of water policy in Algeria. Desalinated water is strictly destined to satisfy the domestic demand of the coastal cities of the country. Conventional water volumes in coastal areas are allocated to agriculture and the interior regions of the country by water transfers. Desalination also aims to reduce pressure on groundwater suffering from overexploitation. The SDP is not the exception to the rule of under-utilization of capacities. In fact, for technical reasons, but often because of management and operational factors, the SDPs are used below their nominal capacity (actual capacity). The volumes produced are not valorized in the downstream of this SDPs, with colossal production costs of the m$^3$, for example, the cost of desalinated water from the SDP of El Hamma (Algiers) is 0.82 US$/m$^3$, the desalinated water is affected in dilapidated, defective and poorly maintained networks. The use of seawater desalination requires highly efficient water distribution networks.

In 2013, the performance of SDP is measured by the ratio of actual production and nominal capacity. The average national performance in the studied SDPs does not exceed the threshold of 62.57%, thus idle capacity is estimated at 34.43%. The performance varies from one station to another. It is, in fact, 38.86% for the SDP of Souk Tlata (Tlemcen), 30.22% for the SDP of Honaine (Tlemcen), 58.53% for that of Sidi Djelloul (Ain Temouchent), and it is limited to 41.5% for the SDP of Arzew (Fig. 2). A paradox must be noted here: while the acute water scarcity is particularly prevalent in the Western region of Algeria [4] and the desalination plants are located in this region primarily to compensate for the lack of conventional water, it is clear that this logic is not respected all the more as the performances improve in the Eastern region, for example in the SDP of Fouka (Tipaza) the rate exceeds 86.5%, El Hamma (Algiers) 89.1%, Cap Djinet (Boumerdes) 77.22% and the Skikda station heads all of them with 97.36% that means an almost optimal use of installed capacity. Furthermore, for the 21 small monoblock stations, the average yields (performance) do not exceed 46% of the nominal capacity [44]. The same report mentions the state of the El Hamma station, which produces 75% of the nominal capacity because of the turbidity and the sludge content of the waters in the Bay of Algiers. The low performance can also be explained by power cuts, production breakdown for maintenance and aging of technical installations. According to MWR data consulted in 2019, it seems that the situation did not improve significantly between January and June 2017, where the performances of Kahrama (Oran) SDP was 56%, 66 % for Mostaganem SDP, 64% for Mactaa (Oran) and 72% for Ténes (Chlef) SDP.

It should be noted that even the capacity of WWTPs is underused. In 2009, for the 61 WWTPs managed by the National Sanitation Office (NSO), the national average rate of under-utilization was 67.53%, on a national installed capacity of 249.98 Mm$^3$ only 81.15 Mm$^3$ was used. This is explained by a low connection rate of these WWTPs to the wastewater collection networks and an intended over-sizing of infrastructures to cope with unexpected seasonal increases

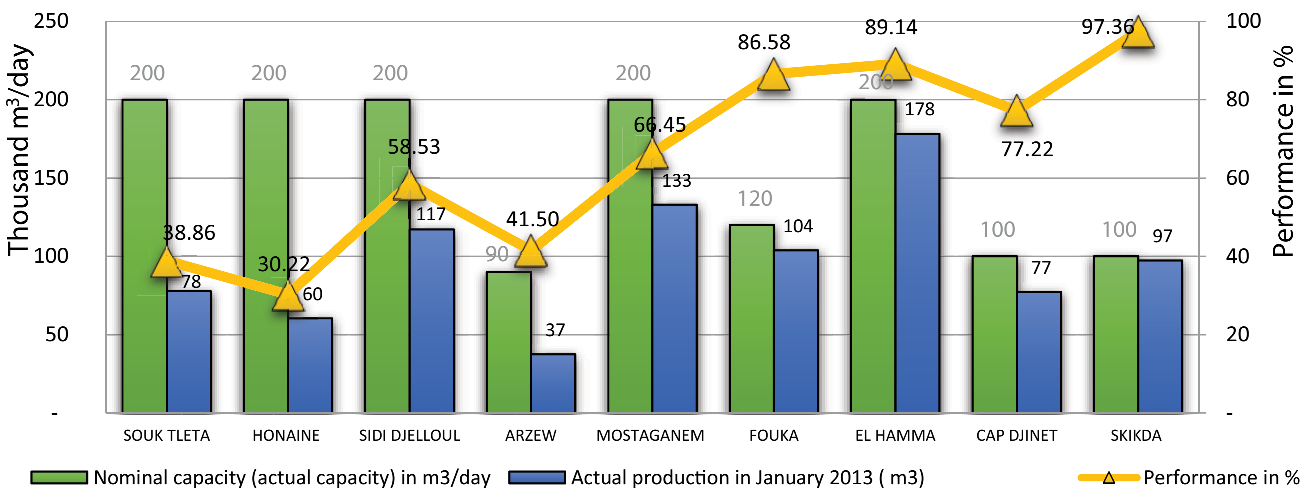



Fig. 2. Performance and under-utilization of seawater desalination plants (January 2013).
*Source*: Compiled by the author, AWC data.

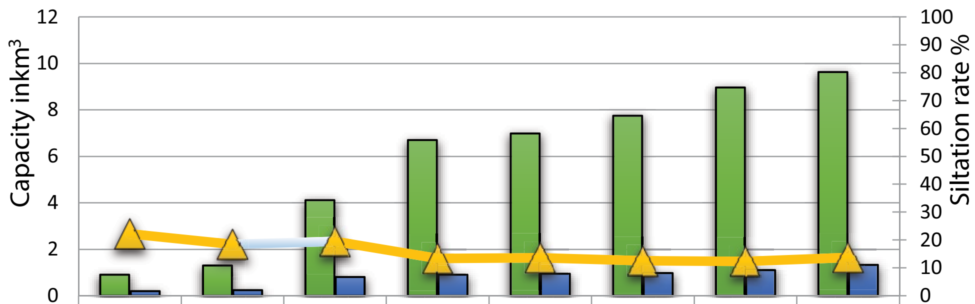
in wastewater discharges especially for coastal areas during the summer period (precautionary principle).

### *3.4. Siltation of dams: problem of a loss in storage capacity*

Dams constitute one of the pillars of water policy and the main axis of the supply model in Algeria. The storage capacity of the 75 dams in Algeria at the beginning of 2017 is 8.1 Bm$^3$. Thus, the per capita storage is estimated in 2017 at 113.8 m$^3$. In fact, it is much lower than the ratios of developed countries such as the United States and Australia (5,000 m$^3$), to that of an emerging country such as China (2,200 m$^3$) and even to the ratios of countries whose economic size is comparable to Algeria such as Morocco (500 m$^3$) and Tunisia (360 m$^3$) [48]. To mitigate its water deficit and thereby to increase the storage capacity. Algeria undertook an ambitious program of water mobilization by 2030, which will allow an additional mobilization of some 2 Bm$^3$ compared to 2010 and this through a proactive and costly public investment policy [46].

This park contributes significantly to water mobilization in the country. Initially, the dams were destined for agricultural uses or mixed uses (agricultural and satisfaction of domestic water needs). However, the increase in water demand, through the combination of several factors has led to structural changes in the water allocation to satisfy the drinking water demand given the regulatory prioritization of this component in Algeria. Currently, dams are subject to vehement criticism due to their adverse impacts on the ecosystem (evaporation, harmful impacts on users and the downstream biodiversity, etc.). Among these effects, the phenomenon of siltation, which causes considerable losses in the mobilization capacity and the storage capacity of water resources. These capacities are affected also by soil quality highly erosive, extreme events such as floods and drought and the absence of the vegetation cover (due in particular to overgrazing and deforestation) in the watershed of the dams. No one can deny the favorable development in terms of the construction of the dams since independence, but it remains that their capacities are constantly exposed to the problem of siltation (Fig. 3).

The rate of siltation in Algeria is among the highest in the world. This phenomenon reduces drastically the storage capacity of dams. In 1957, the siltation rate was 22.2%, while the capacity is estimated at 0.9 Bm$^3$. However, since 1999, the siltation rate has started a downward trend with 13.4% in 2006, 13.6 in 2010 and 12.52% in 2013. It is projected at reach 13.7% in 2030. However, in absolute terms, siltation continues to increase. In absolute terms, siltation continues to increase, in 2000, it was estimated at 800 Mm$^3$ and in 2010 at 950 Bm$^3$, whereas it is 970 Bm$^3$ in 2013 (Fig. 3). The scope and the risk of siltation should not be minimized since the majority of dams are involved in structural projects and large water transfers. The case of the Ighil Emda dam (Kherrata) presents a typical case on which the development objectives of the high plains of Sétif have been designed. Whereas this dam suffers from siltation of 47% of the estimated initial capacity of 154 Mm$^3$. This project consists to transfer 119 Mm$^3$/y to the Mahouane dam to irrigate 16,000 ha of land (66 Mm$^3$) and to meet a part of the drinking water demand of 12 municipalities 56 Mm$^3$ (a population of 1,106,770 inhabitants by the year 2040). To do this, it is necessary to mobilize effective solutions to prevent the phenomenon of pollution. Consequently, the decline in the siltation rate was not the result of a curative and preventive policy, but it was merely the sequence of the increase in the number of dams received in recent years (2000–2018) hence the existence of a compensation effect between the old and the dams recently realized. It should be noted that Algeria built only 7 dams between 1990 and 1999, whereas between 2000 and 2018, it built 28 dams. For [55–57], the phenomenon of siltation is not fatal, but it is a flagrant sign of a failure in taking charge of upstream dams. Moreover, siltation is a constraint that must be urgently solved, especially as some dams will see a capacity loss of more than 20% throughout the next 20 years. These include the dams of Cheurfa II (Mascara), Ghrib (Ain Defla), Gargar (Relizane), Oued Mellouk (Ain Defla), K'Sob (M'sila) and Foum El Gherza (Biskra). The phenomenon of siltation will entail, by 2030, for about ten dams in Algeria a reduction in the storage capacities that can range from 13% to 100%. The most threatened dam is that of Foum El Gherza, which risks a total and premature siltation by 2020,




| | 1957 | 1962 | 2000 | 2006 | 2010 | 2013 | 2020 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Initial Capacity (Hm3) | 900 | 1300 | 4108 | 6704 | 6980 | 7747 | 8957 | 9626 |
| Cumulative silting (Hm3) | 200 | 240 | 800 | 898 | 950 | 970 | 1100 | 1325 |
| Seltation rate (%) | 22.22 | 18.46 | 19.47 | 13.4 | 13.61 | 12.52 | 12.3 | 13.76 |

Fig. 3. Siltation of dams in Algeria.
*Source*: Compiled by the author, [47] and MWR data.

and which will have to be the subject of a special treatment to fight against siltation.

Finally, the Algerian hydraulic model is marked by an economic aberration. A large proportion of the water resources mobilized by the dams remain without valorization. In fact, at the time when water policy sets the axis of seawater desalination as a priority with sometimes prohibitive costs, large volumes of water are stored in dams and they are exploited neither in agriculture nor in the satisfaction of domestic needs. This is due to several factors, including delays in the receipt of irrigation projects and water transfers infrastructures.

### *3.5. Dependence on foreign economies: a multidimensional subordination*

Water scarcity in Algeria coupled with efforts to overcome this problem, through a supply policy, has anchored a situation of transversal dependencies. Indeed, the water scarcity is seen as a limiting factor of agricultural development, the thing that has generated food dependence. The investment effort accelerates a technological and engineering dependence on foreign countries.

#### *3.5.1. Technological dependence by hydraulic equipment import*

From an economic point of view, investments in the water sector are ineffective to meet water problems [5]. The budgetary effort, in terms of capital expenditure, was combined with the realization of sophisticated infrastructures. These public investment programs have created additional demand, but in the absence of national means of production, the satisfaction of this demand is directed towards the outside. This has created a perverse effect of technological dependence and hydraulic equipment import from foreign countries far from stimulating local production. The director of the AWC accused the national companies of a lack of competitiveness. The case of Altumet, a subsidiary of Anabib, specialized in the manufacture of metal tubes which is currently facing financial difficulties threatening its activities. According to this director: "*the company products are expensive and we import from Turkey a similar range at lower prices*". Moreover, this dependence is not specific to the water sector, but it affects all sectors of the economy and it makes Algeria a net importer of technology.

The analysis of the import trends of three highly demanded products in the water sector between 2000 and 2010 shows that subordination is pregnant. The first is the pipes and tubes, its import bill is constantly increasing from one year to the next and it rose from 17.86 million US$ in 2000 to 2.38 billion US$ in 2010. The import bill for the pumps has followed also the same trend. It reached a peak of 272 million US$ in 2010, whereas it was 22.5 million US$ in 2000. It is now obvious that although the import of water meters increased during the period 2000 (132,000 US$) to 2010 (1.26 million US$), this increase remains low and insufficient. It shows the lack of care in the applying of WDM principles. Besides, the volume of drinking water distributed but not billed (commercial losses) reached more than 58.6%.

#### *3.5.2. Dependence on foreign engineering "know-how"*

Dependence is not only concerning the import of highly sophisticated equipment, but the tasks associated with their construction, management, and maintenance are extremely interdependent and cause complex and real dependence positions. We can't see how a project whose feasibility studies are carried out by a foreign engineering office and whose realized by foreign construction groups is conceded to be managed by the national public companies. These companies are financially deficient in view of their blatant accounting deficits, disproportionate public subsidies and a clear weakness in institutional accountability. In addition, with the deficit of maintenance expenditures, this equipment could be declined over time which further complicates the water problem. In all major projects and great transfers received or to be received in Algeria, engineering office and foreign companies are involved in a large-scale (Table 3). Consequently, the public investment programs initiated during the period 1999 to 2019 have not been able to create a national tool of engineering and realization and they have not been able to provide a technological transfer to domestic companies, despite the regulatory obligation of a partnership between the foreign investor and a local company.

#### *3.5.3. Food dependence: what about food self-sufficiency?*

The relation between water scarcity and agricultural production and hence food self-sufficiency is established. The per capita water availability is very low to be able to achieve food self-sufficiency in Algeria and the indicators of scarcity are in alarming position [2–5,7,8,11]. To refine the impact of water scarcity on meeting food needs, Malin Falkenmark notes that food self-sufficiency is acquired only above the norm of 912 $m^3$/cap/y [12]. In sum, every country must have 2.5 $m^3$/cap/d (day) as a norm to hope for self-sufficiency [12] mentioned that with the population growth countries will be in 2025 into four categories namely: countries where food self-sufficiency is possible and feasible (South-East Asia region); countries that could achieve it with a water-saving strategy (WDM) (region of Caucasus, Kazakhstan and Central Asia); Countries where the challenge of self-sufficiency would become problematic (Southern Africa region, northern China, West Africa, East Africa) and countries where food self-sufficiency will be impossible and unfeasible (North Africa, South Asia): "*[…] Already the population growth rate makes it unrealistic to supply water on the same per capita level as is supplied at present; food self-sufficiency needs to make it even more unrealistic […]*" [12].

The solution to this problem is the food import from foreign countries. However, this remedy is not the panacea insofar as it accentuates dependence. The situation of Algeria in this wake is edifying. Algeria imports almost 17.31 $Bm^3$/year as virtual water. This volume would exceed the natural potential resources (16.4 $Bm^3$) and the exploitable water resources with (10.47 $Bm^3$) [5,58,59]. The coping strategy to water scarcity via the virtual water trade can't be mobilized sustainably and forever, also there is a need for adaptation strategies that can reduce the intensity of this food dependence. According to National Agency for the Promotion of Foreign Trade (*Agence Nationale de Promotion*

Table 3
Involvement of foreign companies in feasibility studies and the realization of some great water projects in Algeria

| Project | | Country of the company |
|---|---|---|
| Engineering of the transfer: in Salah Tamanrasset | | Consortium: STUCKY-BG-IBG (Switzerland) |
| Transfer of Koudiat Acerdoune | Dam of Koudiat Acerdoune (Bouira) | Engineering: COYNE and BELLIER (France)<br>Construction work: RAZEL SA (France) |
| | Lot *n*°1 (Bouira and Tizi Ouzou) | Construction work: Consortium: SNC LAVALIN international INC/ETRHB HADDAD/SNC LAVALIN MAGHREB EURL (Canada/Algeria)<br>Engineering: Consortium: STUCKY/ENHYD (Switzerland/Algeria); |
| | Lot *n*°2 (Bouira and M'sila) | Consortium Algerian/Egyptian: KOUGC/ARAB-Contracting/HAMZA Associated |
| Transfer High Plains of Sétif | Transfer: Ighil-Emda – Mahouane | Consortium Algerian/Egyptian KOU.GC/A.C.C |
| | Tunnel: Tabellout-Draa Diss | C.M.C DI RAVENNA (Italy) |
| | Dam of Tabellout | RAZEL (France) |
| | Transfer of Tabellout-Draa Diss | MAPA INSAAT (Turkey) |
| | Dam of Draa Diss and Mahouane | CHINA INTERNATIONAL WATER & ELECTRIC CORP (CWE) (China) |
| | High Plateaus of Sétif (HPS) | Engineering SAFEGE and COYNE and BELLIER (France) |
| Dam and transfer of Boussiaba (Jijel) | | Construction work: Consortium ZAGOPE/ANDRAWC GUTIERREZ (Portugal/Brazil);<br>Construction work: RSW Inc. (Canada) |

*Source*: Realized by visits of projects and other references.

*du Commerce Extérieur*) (ALGEX) statistics, food import bill of Algeria, as well as the global import bill, has risen significantly in recent years from US$2.415 billion in 2000 to a level of US$7.585 billion in 2007 before reaching US$6.034 billion in 2012 and US$7.68 billion in 2014 and according to the General Directorate of Customs, the food import bill has declined relatively for the first 11 months of 2016 to reach US$7.53 billion.

### *3.6. Water policy in Algeria: lack of institutional coordination and multi-level governance gaps*

The construction of institutions has a major role in the strengthening of the social capital[15] insofar as it facilitates the emergence of multi-level and multi-stakeholder cooperation in water management [31,32,35]. Moreover, [37] and [38] advocated collaborative, flexible and dynamic multi-level governance with horizontal and vertical coordination to overcome deficits. The guarantor of the effectiveness of adaptive capacity is the presence of adaptive and participatory governance based on clearly defined institutional arrangements and it is necessary to avoid the traditional top-down process to the new bottom-up process. Therefore, we can already investigate the applicability of such approaches in Algeria.

Indeed, the [45] highlights the importance of the participatory approach to agricultural water management, but in this context, we note a lack of a culture of participation and collaboration between users (farmers). Moreover, the SMH is currently managed largely by the individual mode at 83% of the irrigated area (the irrigated area in SMH has reached 1,306,361 ha in 2018 this one was 350,000 ha in 2000), the called collective mode remains marginalized with 17%, yet it is recognized as the most effective in the agricultural water management. The water sector in Algeria is still constrained by a lack of coordination and collaboration among stakeholders involved in the implementation of the national water policy shows a policy gap despite the existence of two authorities guaranteeing in principle these tasks namely the NACWR and the RBC. According to a central director in MWR: "*Despite its strategic role, the NACWR meets only occasionally. Its last meeting was held in 2016. This is due not only to the difficulty of bringing together all the bodies concerned because it is an intersectoral and inter-ministerial body. But it must be said, members have no compensation if they attend this council, which demotivates them*".

Lack of coordination and communication leads to dilution and fragmentation of responsibilities between water institutions and actors. Thus, we find a fracture in the horizontal institutional coordination at the higher level, as

[15]Social capital is defined by the characteristics of social organization as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit. A high level of social capital results from low transaction costs in the provision of public goods and the improvement of the quality of the environment [32,33].

the different ministries and other actors communicate little between themselves and the coordination between the central directorates of the MWR is insufficient; a fracture of horizontal institutional coordination at the lower level (at the sub-national level) from the moment when the users themselves do not communicate (case of agricultural water); A fracture in vertical institutional coordination between the different levels of administration at the local, regional and national levels (MWR, river basin agencies (RBA) and water resources directorates of wilayas).

The vertical and horizontal coordination is considered as a pillar of adaptive governance and a source of institutional learning [36]. Institutional learning requires two conditions sine qua non. Firstly, the capacity to collect and process the information on the governance system (all water resources data). This constitutes an informational capital that structures adaptive capacity. Secondly, the capacity to disseminate this information to all those who need it (actors, users, and researchers) [36]. These two conditions are facilitated by the coordination and integration of users into the management networks. In Algeria, the information gap has been well highlighted, starting with the unavailability of reliable information on the water potentialities, the volumes mobilized and economic information on funding and investment in the water sector (absence of the first component of institutional learning). When such information exists, there are not effectively disseminated efficiently or used optimally. Therefore, in the absence of these components (information flows and knowledge attached to them) multi-level governance could not be implemented sustainably and wisely. The Integrated Water Information Management System[16], implemented by the MWR, aims to overcome these constraints of information and communication and thus the construction of institutional adaptive capacity, but to this day it remains without major impact and reform advances through a time-consuming process. Besides, the new approaches of water management calls for decentralization of public action, but in Algeria, despite the texts that evoke decentralization, the reality on the ground has revealed to us something else: all measures and investment procedures, water mobilization and water resources use are centralized on at large-scale.

Water management in Algeria takes place at river basin level based on recommendations of the national water assizes in 1995 where the conferences were held on 28, 29 and 30 January 1995 at the Club des Pins in Algiers. They were preceded by regional meetings where the views, suggestions, reflections, and contributions of some 15,000 participants were gathered, ordered and subjected to a confrontation at the level of the workshops. This management at the river basin level is strengthened after by the water law in 2005, but the great geographical extent of the country means that this management at the river basin does not agree with the administrative limits of the wilayas and municipalities. The "mismatch" between functional areas and administrative boundaries" [38] has made an administrative gap of the multi-level governance process. This deficit generates access conflicts to water resources between the different user categories, which affects the satisfaction of the needs. Thus, notwithstanding all the reforms undertaken over the years following the IWRM principles, legal instability and the inability to implement actions dictated by law show a capacity gap. There is a weakness in the scientific and technical capacities of the activating staff in the water sector. The intense needs for capacity building involve necessarily an increased training cost. Certainly, the water sector in Algeria does not need to increase the number of staff quantitatively, all the more so that the number of functionaries per 1,000 subscribers is 7.58 and 6.93 employees in 2013 and 2017 respectively[17], but above all to improve qualitatively this intellectual capital. Knowing that in most countries the ratio does not exceed 4 employees; In Windhoek (Namibia) there are 2 employees per 1,000 subscribers, Chile (1.1 employees), Morocco (3 employees), Iran (3.5 employees) [48].

The financing cycle of the water sector suffers from an endogenous funding gap to the water sector, given the existence of substantial water subsidies and the difficulties encountered by water institutions (AWC, NOID, municipalities, and RBA) in applying the pricing measures and to sustainable cost recovery. Moreover, according to MWR data consulted in 2019, the receivables portfolio of AWC towards its subscribers was valued at 47.72 billion DA (almost 399.1 million US$) in 2017, or an increase of 45.84% compared to 2012 when they were 32.72 billion DA (420.5 million US$)[18] and 72.21% compared to 2010 with receivables portfolio of 27.71 billion DA (356.2 million US$). The NOID is faced with the same problem, as farmers refuse to pay the water tariff, considering it a gift of God and therefore without market value. According to an official of NOID: "*Deterioration of the financial situation of the NOID is not only due to farmers who do not pay for water, but rather to the aspect of prioritizing drinking water over agricultural water. If a subsidy for water services exists it is because the State provides tariff compensation (the difference between the actual price of water and the administered tariff). However, NOID receives rarely this compensation compared to the other institutions in charge of drinking water, as the case of the AWC*".

In sum, this shows a reluctance to pay the water services and a rejection of the WDM alternative. This does not in any way agree with the "water pays for water" principle and it presents a major obstacle to the WDM. In contrast, public investment programs have endowed the water sector by immense budgetary envelopes. These budgetary allocations certainly made it possible to avoid an exogenous funding gap, but the deficiencies are not lacking in particular because the origin of these funds is characterized by volatility and instability coupled with absorption constraints of

[16]This framework was initiated by article 66 of the Law No. 05-12 relating to water and renforced by the publication of the decree of 2 February 2011 setting out the procedures for access to data in the Integrated Water Information Management System (*Système de Gestion Intégrée de l'Information sur l'Eau*).

[17]Ratio calculated for the AWC that counted in 2013: 24,342 employees and 3.21 million subscribers. In 2017, the AWC had 31,350 employees and 4.52 million subscribers.

[18]The decrease of the receivables portfolio of AWC from 420.5 million US$ to 399.1 million US$ between 2012 and 2017 is still due to the sharp devaluation of the dinar.

these amounts (in 2012, the absorption rate does not exceed 38.69%).

## 4. Conclusions

Despite the difficulties in accessing data due to the information gap, we were able to complete the study. However, this analysis of the existing weaknesses and shortcomings of water policy in Algeria is so far from exhaustive. If the current orientations continue in the same direction, namely a supply-side management, the technical model "hydraulic mission" and the hard path, we must expect a complication of these weaknesses and the appearance of other limits. Water resources in Algeria continue to incur from multiple aggressions leading to worrying pollution situations. The current water policy focusing on long-distance transfers involves the risk of large-scale pollution, for example, if the dam of Beni Haroun becomes polluted, this will affect all the wilayas interconnected by this system. Same situation with the transfer of Koudiat Acerdoune, the transfer of High Plains of Sétif and the transfer of Mostaganem-Arzew-Oran (MOA). Consequently, the deficiencies in the current water policy dictate urgently a transition towards serious WDM. Thus, founding a break with this traditional approach, which focuses on simple water mobilization and a search of technical solutions to a transversal problem notably economic and social is more than an imperative. Algeria has successful the challenge of water mobilization during the period 1999 to 2019 and it has been able ipso facto to achieve targets related to water and sanitation in goal 7 of the MDGs before the UN fixed deadline in 2015. The current challenge is to succeed in the challenge of downstream water valorization and to prepare the achievement of sustainable development goals by 2030, in particular, the goal 6: "*Ensure availability and sustainable management of water and sanitation for all*", especially in the context of a decline in public investment since 2009 (Fig. 1).

The results of the study show that despite the compatibility of the Algerian hydraulic model with the paradigms presented by [39], water uses in Algeria have not decreased, on the contrary, all efforts have led to a phenomenal increase in water withdrawals and hence in water uses. According to the MWR, the drinking water demand has increased from 1.25 $Bm^3$ in 1999 to 3.6 $Bm^3$ in 2015. This has led the scarcity indicators to critical levels [2–5,7,8,11,21]. Therefore, Algeria is still in the second paradigm of the hydraulic mission, although the stated objectives, the legal texts, and the official discourse affirm that the Algerian model is cited as an example. These indicators make it possible to say that water policy in Algeria is in the transition phase. The need for WDM implementation, an application soft path approaches, and multi-level governance is mainly due to the recognition of the shortcomings of a policy based solely on an increase in the water supply. This is supported by two arguments. On the one hand, the water supply is no longer unlimited, as exploitable water volumes are increasingly scarce, technically difficult to domesticate and economically expensive to transfer. On the other hand, mobilizing water without knowledge of a natural limit of the resource and without awareness of users to save water would be blatant nonsense in a scarcity context, hence the imperative passage to the WDM. In addition, the import of virtual water is being mobilized by several countries, including Algeria, even before the implementation of the preliminary stages of WDM, in particular, the end-use efficiency and the allocative efficiency. In this regard, we judge that Algeria has not given sufficient attention to the two stages of WDM to move directly to the import of virtual water. In Algeria, irrigation uses almost 65% of total water withdrawals [5], the leakage in drinking water distribution networks is still considerable and the use of economic instruments with a price-signal is marginalized for both political and social reasons, which means that there is substantial and irrefutable scope of maneuver in terms of water-saving. Consequently, there is a potential that has not yet been exploited in order to improve the use efficiency like the possibility of converting gravity-fed irrigation systems into water-saving systems (drip and sprinkler irrigation technologies), we note that 21% of irrigated areas in 2011 were in drip irrigation mode before reaching 49% in 2015; the fight against water wastage through the installation of the metering means; the reactivation of water police which is a source of water resources preservation. Regarding the second stage of WDM "allocative efficiency", it would not be fully applicable in the Algerian context given the high degree of social stress, conflict and political stress that its implementation implies. It requires an important development level that facilities economic arbitrage between different water uses.

Finally, the water challenge is of major importance for Algeria, where population growth will exert pressure on water resources by 2030, thus exacerbating the water scarcity. The water funding strongly correlated with oil prices, these have decreased since 2014 of 112 US$/barrel to reach 61,16 US$/barrel in December 2019, would induce ceteris paribus Algeria again in a position of economic water scarcity and water poverty with a first-order resource scarcity (water scarcity) and second-order resource scarcity (absence of the adaptive capacity) [5,42]. Therefore, it is time to reduce the transition period from supply-side management to demand-side management (WDM) and to valorize the resources already mobilized. Nowadays, the context is not favorable for water sector, especially in the current economic conjuncture with the decrease of water funding and an unstable political situation as a result of a people's revolution (*revolution of the smile or Hirakmovement*) triggered since 22 February 2019, demanding the departure of the regime and therefore a probable and global overhaul of the planning frameworks already established and in progress.

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