

Dam engineering in Algeria: progress, needs and prospects

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This paper describes the potential for future water resources development in Algeria, as well as some key aspects of dam engineering, past and present. One current issue discussed is reservoir siltation, which is reducing the storage capacity of dams.

In terms of water resources, Algeria is among the poorest countries of Africa and the world. Therefore, one of the constant preoccupations of the relevant authorities is to try to resolve the delicate balance between maintaining water resources and meeting water needs.

To reach a satisfactory level of security in water supply, it would be necessary to commission between 15 and 20 × 10⁹ m³ of storage per year by 2025. This is a major challenge, considering currently only 7 × 10⁹ m³ is developed each year.

Another challenge is that major erosion which affects the northerly plains is decreasing both the agricultural potential of the country and the capacity of water resources that can be mobilized.

1. Runoff potential of Algeria

Algerian territory covers about 2.4 × 10⁶ km². However, 90 per cent of this area is desert, where precipitation is virtually non-existent. The potential of renewable water resources is concentrated in the north of the country, which contains basins dependent on the Mediterranean Sea and those of the high plateaux. The rainfall in this region varies from 200 mm/year on the high plateau to 1600 mm/year on the mountains of the Atlas Tellien bordering the Mediterranean. Besides this north-south variation, one can observe an increase in precipitation from west to east.

The runoff potential is governed by Algeria's arid to semi-arid climate. The potential is thus very low, and corresponds to only around 20 × 10⁹ m³, of which it would only be possible to develop about 12.4 × 10⁹ m³.

The Algerian territory is sub-divided into five hydrographic basins (see Fig. 1 and Table 1). This helps to correlate resources with areas of greatest need. The basins are:

- Oranie - Chott – Chergui;
- Chellif – Zahres;
- Algérois - Hodna – Soumam;
- Constantinois - Seybouse Mellegue; and,
- the South.

The spatial disparity of water resources indicates that the first two of the hydrographic basins listed above (which represent about 35 per cent of the total surface of the Atlas Tellien mountains), receive only around 8 per cent of the total runoff.

The Constantinois - Seybouse Mellegue basin is the region richest in water resources, receiving nearly 39 per cent of the annual flow volume of the country.

In the South, the availability of runoff is also low. However, sub-terranean water resources are substantial.

To resolve the delicate balance between water resources and meeting water needs, the authorities in Algeria have been forced to mobilize the maximum potential of water available, which combines non-conventional, subterranean, and surface **aters**.

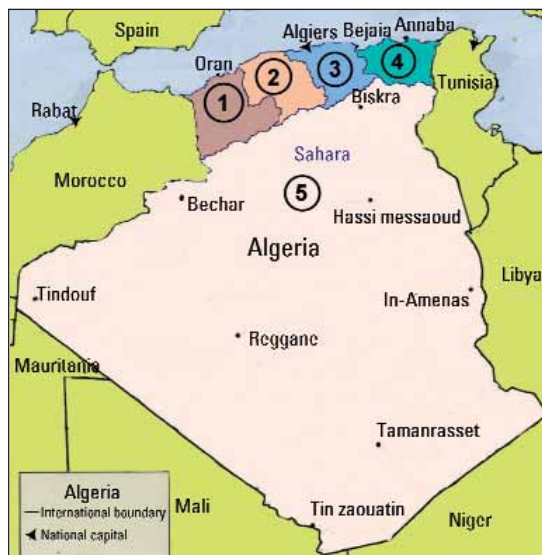


Fig. 1. Map showing the distribution of the hydrographic basins in Algeria.

Table 1: Spatial distribution of the surface waters in Algeria

Hydrographic basin	(1)	(2)	(3)	(4)	(5)	Total
Resources (10 ⁶ m ³ /year)	1025	1840	4380	4500	600	12.34
Percentage	8.7	15.7	37.3	38.3	0.48	100.0

2. Mobilization of the runoff

The construction of dams to exploit the country's runoff became a major concern throughout the 19th Century. The first dam built in Algeria was Meurad,



Foum El Gherza dam (1950).



Sarno dam (1954).

Capacity (10 ⁶ m ³)	Number of	Total capacity (10 ⁶ m ³)
>500	2	1610
500 > V > 250	4	1360
250 > V > 200	4	889
200 > V > 100	16	2278
100 > V > 80	4	342.1
80 > V > 60	6	425.1
60 > V > 40	11	535.5
40 > V > 20	8	229.5
V < 20	10	107.3
Total	65	7776.5

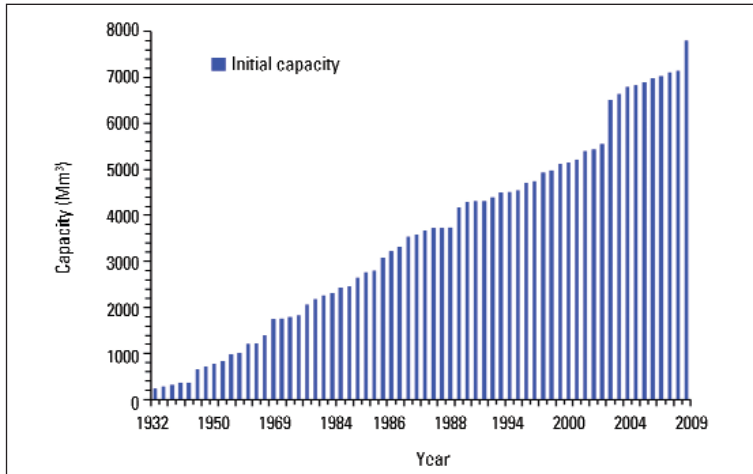


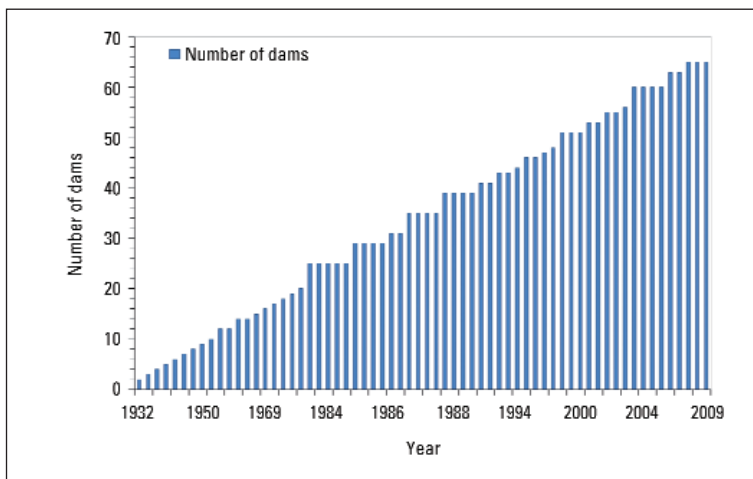
Fig. 2. Increase in storage capacity.

constructed in 1861. Other dams were built during the period 1846-1885. However, these experienced a number of design problems, because the necessary engineering techniques had not yet been fully mastered. From 1930, dams with larger capacities began to be built.

The 11 large dams built before 1962 (the year of the Algeria's independence) had an initial capacity of about 1×10^9 m³ and regulated an annual volume estimated at about 600×10^6 m³. It is noteworthy that by 1962, silting of reservoirs had affected 20 per cent of the total storage capacity, which totalled about 200×10^6 m³.

Since 1962, a further 54 dams with a capacity of at least 10×10^6 m³ each were constructed, increasing the total storage capacity of dams in Algeria to about 8×10^9 m³ (see Table 2).

Fig. 3. Evolution of the number of dam in Algeria.



View of Beni Haroun, Algeria's largest dam.

More than ten major dams are currently under construction.

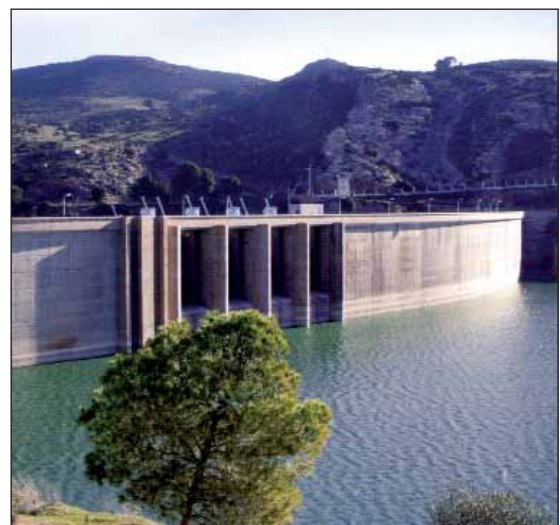
The Algerian dams are of average capacity, the largest being: Beni Haroun, with a capacity 960×10^6 m³; Kouliat Acerdoune (650×10^6 m³); Gargar (450×10^6 m³); and, Djorf Torba (350×10^6 m³). Experts have stressed that the hydrological conditions of Algeria do not allow for dams of very large capacities.

To reduce the deficit of water storage, the Algerian Government foresees the construction of 110 more dams in the future.

Of the total of 65 large dams in operation, the breakdown of types is as follows: 42 are earthfill, eight are rockfill, five are concrete gravity, two are arch, four are multi-arch, three are RCC dams, and one is masonry.

The last seven years (2003-2009) saw an important evolution in the mobilization of the runoff, estimated at 2243.15×10^6 m³ (29 per cent of the total capacity). This progress was achieved through the construction of ten dams with large capacities, including Beni Haroun and Kouliat Acerdoune dams.

The 65 dams in operation are distributed between the various hydrographic basins as shown in Table 3.



Cheufas II dam (1992).



Ksob dam (1976).

Monitoring and implementation of plans and programmes for the mobilization and transfer of surface water resources is the responsibility of the National Agency of Dams and Transfers (ANBT).

According to the latest evaluations, the dams with a capacity of more than $10 \times 10^6 \text{ m}^3$ in operation allow for the regulation of an annual volume estimated at $4 \times 10^9 \text{ m}^3$ of water, representing about one third of the exploitable potential. This does not take into account the volumes used for the hydropower production at the Erraguene and Ighil Emda dams.

3. Reservoir siltation

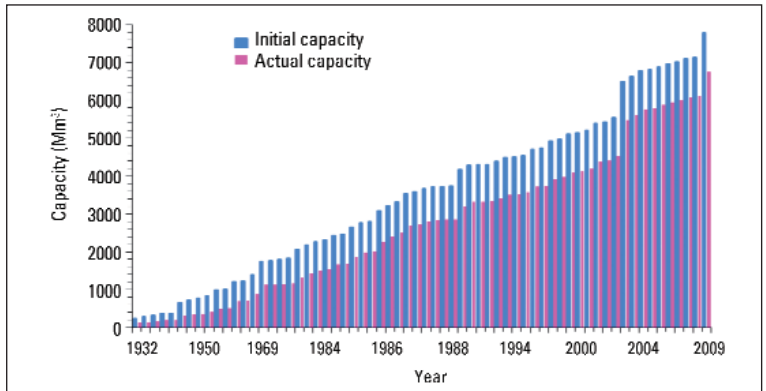
The climate in Algeria is characterized by rainfall of short duration and strong intensity, which generates floods, mainly in the autumn, and causes the erosion of young relief in areas where vegetation cover is poor. As a result, the silting of reservoirs can occur rapidly, and this leads to a significant loss of storage capacity. The last bathymetrical survey carried out by the national Agency of the Dams, in 2004, showed that siltation had reached a volume of $1.05 \times 10^9 \text{ m}^3$, representing 13.5 per cent of the original total capacity. This has reduced total storage capacity from $7.78 \times 10^9 \text{ m}^3$ (Fig. 4).

The average rate of silting of dams built before 1970 is 57 per cent, which is 8.2 per cent of the total initial capacity of Algerian dams. The rate is less significant for dams built during the period 1970 to 1990, for which the average is 15.3 per cent, representing 4.4 per cent of the initial total capacity. For dams built over the last 20 years, the average rate of silting represents only 1.5 per cent, that is 0.6 per cent of the initial total capacity (Fig. 5).

The rate of silting of dams in operation increases with the age of the dam. In this sense one can find some cases of dams for which the rate of silting is high, in particular: Fergoug (1970) 78 per cent, Fom El Gherza (1950) 68 per cent, Boughzoul (1934) 63 per cent, Ksob (1976) 60 per cent, Ghib (1939) 59 per cent, Ighil Emda (1954) 55 per cent, Oued Fodda (1932) 54 per cent, Bou-Hanifia (1948) 48 per cent, Zardezas (1974) 40 per cent, SMBA (1978) 36 per cent, Mexa (1998) 35 per cent, Bakhadda (1936) 28 per cent, Hamiz (1935) 26 per cent, Beni Amrane (1988) 26 per cent, Djorf Torba (1969) 26 per cent,

Table 3: Dams in operation by hydrographic basin

Hydrographic basin	Number	Capacity (10^6 m^3)	Percentage
Oranie (1)	13	768.7	9.89
Chélif-Zahrez (2)	14	2109	27.12
Algérois-Soummam-Hodna (3)	15	1711.35	22.00
Constantinois-Seybouse-Mellègue (4)	19	2612.45	33.59
South (5)	4	575	7.40
Total	65	7776.5	100



and Gargar (1988) 20 per cent. This situation translates to a loss of storage which involves the non-satisfaction of water needs.

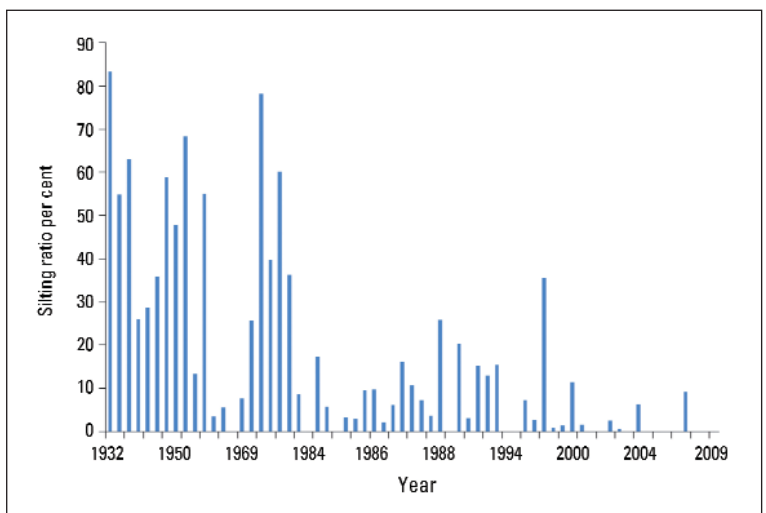
Fig. 4. Reduction of the initial capacity of dams by the silting.

4. Possible solutions for the problem of siltation

To remedy the problem of silting, several solutions have been recommended. These are generally curative, such as the construction of new dams, heightening of dams, the construction of desilting basins upstream of dams, dredging by various processes, and so on. All these remedial measures have been used in Algeria. (Reconstruction of Fergoug and Cheurfas dams, heightening of Bakhadda, Hamiz, Zardézas and Ksob dams, a desilting basin for Boughzoul dam, and dredging at the Fergoug, Zardézas and Fom El Gherza dams).

The solution of heightening the sill weirs by adopting a P.K.Weir represents an interesting and economic alternative. A summary study of this solution for 13 Algerian dams showed that this solution could recuperate $400 \times 10^6 \text{ m}^3$ at a very low cost.

Fig. 5. Rates of silting of dams in operation.



5. Conclusion

The water resources of Algeria are limited and distributed unevenly throughout the country. This makes it difficult to mobilize and manage these resources. In spite of these challenges, experts are endeavouring to reduce the water deficit and reach a more balanced distribution of water resources throughout the country.

The Algerian Government has set up a strategy of development for the water sector, based in particular on mobilization of runoff and subterranean water resources, as well as combatting the loss of water resources through rational management.

This strategy is based on a programme of development, in particular on the construction of dams, and the interconnection of several dams via water transfer systems to all the regions of the country.

The runoff potential is estimated at $20 \times 10^9 \text{ m}^3$, of which $12.4 \times 10^9 \text{ m}^3$ is exploitable. At present, Algeria has 65 dams which had an initial capacity of about $8 \times 10^9 \text{ m}^3$ (that is, 75 per cent of the exploitable resources), but this capacity has been reduced to $6.7 \times 10^9 \text{ m}^3$ because of silting, which exceeds $1 \times 10^9 \text{ m}^3$.

To reach a sufficient rate of water resources development, several dams are under construction or study. Their commissioning will provide a total storage capacity of about $10 \times 10^9 \text{ m}^3$. However, the problem of reservoir sedimentation remains a significant challenge, and will require more attention in the future. \diamond

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