CONTRIBUTION OF THE ALGERIAN WATER MANAGEMENT STRATEGY TO THE AGRICULTURAL SECTOR OF SETIF PROVINCE

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Purpose. This study aims to examine the water resource management and transfers in Setif province, Algeria, focusing on their impact on agriculture and economic development. The study aims to understand the effectiveness of implemented strategies such as water transfer, dam construction, seawater desalination and desert water use in optimizing water resources and improving water availability.

Results. The study found that the implementation of water resource transfer in Setif province has led to increase in the supply of drinking water, establishment of industrial complexes, and increased food security. The expansion of irrigated land and significant growth in crop production demonstrate the positive outcomes of this water transfer. However, challenges remain, such as the need to promote modern irrigation techniques, preserve water quality, and address environmental concerns.

Scientific novelty. This research contributes to the understanding of water management in Algeria by providing insights into the experiences and lessons learned from Setif province. The study highlights the importance of adopting contemporary irrigation techniques, raising farmers’ awareness regarding wise exploitation of water resources, and solving water quality problems.

Practical value. The findings of this study offer valuable insights for effective water resource management in Algeria and beyond. The results of the study from Setif province can help to develop and implement water management strategies in other regions, ultimately contributing to improved agricultural production, economic development, and long-term sustainability in the sector.

Key words: building dams, water resource management, great water transfers, irrigation water, agriculture, wells.

Introduction. Algeria has attempted to diversify its water sources by implementing a new strategy based on water resource management across the country aiming to water provision and the promotion of several sectors.

One of the main interlocutors of this technique is the great water transfers. This is done by moving water across the regions, in addition to building dams and using seawater desalination plants to cover this lack of resources recorded in the coastal areas, and transferring the surplus water to the inner cities. It also used the desert water layer to transfer water to the residents of the south. This is done by providing the necessary institutional structure for the best management of the several infrastructures.
in the sector of water. The problem addressed in this article is the management of water resources in Setif province, Algeria, and its impact on the agriculture sector and overall economic development. The research question is: “What is the impact of the Algerian strategy of water resource management?”, including measures such as water transfers, dam construction, seawater desalination, and desert water utilization, on the agriculture sector and economic development in Setif province.

**Review of literature.** The national water resource management technique consists of projects based on providing the necessary supplies of potable water for the entire population, in addition to improving and diversifying agricultural production by expanding the areas of irrigated agricultural areas, by optimizing available water resources (Kherbache, 2020).

In order to ensure the necessary water resources, part of the water from the dams is diverted from the coastal areas towards the interior regions (the High Atlas), and in turn, the surplus of water in these areas is diverted towards the High Plateaus. The deficit in the coastal areas is compensated by the desalination of seawater, and the deficit in the high plateaus is compensated by the transfer of coastal areas and desert water (groundwater). Among the priorities of this strategy include the mobilization of new water resources through:

1. **Dams.** Algeria hosts a variety of dams that play important roles in areas such as water storage, flood prevention, power generation, and irrigation (Neama et al., 2020). The National Agency for Dams and transfers (Fr. Agence Nationale des Barrages et Transferts – ANBT) is responsible for the operation of reservoirs in Algeria (Tebbi et al., 2018). The number of dams in Algeria is estimated at 80 (Algerian Ministry …, 2021), with a total capacity of up to 1.2 billion cubic meters annually. These dams are directed to various uses, focusing on providing water to rural areas, especially those destined for irrigation. A significant issue with water in Algerian dams is the substantial loss of water through evaporation, owing to high evaporation rates (Saggaï & Bachi, 2018). Nevertheless, the dam filling rate is 44.52 %, according to current precipitation levels (Algeria Press Service, 2022). In order to achieve the total capacity of these dams, these projects have been monitored to remove sediment from 11 dams, which then contributes to raising the capacity by 43 million cubic meters.

2. **Repairing water networks.** Once the repair of damaged networks is undertaken, whether in the agricultural sector or potable water, when combined with the use of modern water management technologies this contributes to reducing leaks up to 40 %.

3. **Seawater desalination.** In response to climate change, Algeria has chosen desalination as an alternative approach to address the issue of water scarcity (Djoher, 2020). Currently, there are 10 seawater desalination plants with a total capacity of 1,610,000 m³/m (Algerian Ministry …, 2022). Algeria is also seeking to achieve the goal of establishing 16 huge seawater desalination units.

4. **Wastewater filtration stations.** There are 177 purification stations in Algeria with a capacity of 805 million m³/year, including 49 stations in major coastal cities, as well as 69 purification stations under construction with an estimated capacity
equivalent to the population, which is 244 million m³/year (Algerian Ministry …, 2022).

5. Water Transfer between regions (“Great transfers”). The supply of potable water to the population, in sufficient quantity and at the required quality, is an initial part of the national water policy (Algerian Law, 2005). Therefore, several “great transfers” were carried out, through which an additional volume of water was mobilized. These “great transfers” are:

5.1. Transfers from the eastern side, represented in: Transferring water from the Bani Haroun dam to five states situated in the plains, as follows: Constantine, Mila, Umm El-Bouaghi, Batna, Khanchela. Transferring water towards El Mawan Dam and Draa El Dis Dam in Setif province, which will be shown in the second part of the study (Algerian Ministry …, 2022).

5.2. Transfers from the western side, as mentioned by: the water production system (Chlef-Karata), which ensures the supply of drinking water to the MAO collector’s corridor (Mostaganem-Arzew-Oran) with a rate of 155 million m³/year (Bouchareb, 2014).

Diversion of groundwater south of Tlemcen, north of Naama and in the west and south of Sidi Bel Abbes.

Desalinated seawater channel from Mostaganem supplies the city of Relizane (Algerian Ministry …, 2022).

5.3. Transfers of the southern (desert) side, represented in: The transfer of groundwater from Ain Salah to Tamanrasset along a distance of 750 km with a rate of 588 million m³/year, ensuring the provision of both potable and irrigation water, and 24 wells were drilled to extract water with a pumping capacity of 100 thousand m³/day (Medour et al., 2012). Water desalination stations have also been established, which will improve the quality of water distributed in the south of the country, especially in Tindouf, Ouargla, El Oued, and Tamanrasset (Algerian Ministry …, 2022).

Although the aquifer in the desert region is a non-renewable resource, the current pace of exploitation enables the provision of water for a period that may exceed 2000 years, which is considered sustainable exploitation from a long-term point of view. This strategy contributed to increasing the area of land destined for agriculture, reaching 44 million hectares, which represents 18% of Algeria’s area (Algerian Ministry …, 2021).

6. Water pricing. Resource scarcity compels public authorities to demonstrate a clear commitment to rationalizing public expenditure as a strategic approach (Magri & Berezowska-Azzag, 2019). To ensure a rational and sustainable use of water, Algeria relies on an incremental pricing system for water usage. The higher the amount of water consumed, the higher the unit price of the bill. That is, the criterion of increasing pricing is based on increasing installments for domestic consumption, as well as the criterion of pricing discrimination based on consumer categories (families – management and services – industrial and tourism units), since the pricing for industry, tourism and services is estimated at 25 DZD/m³.

Materials and methods. This study aims to examine the water resource
management and transfers in Setif province, Algeria, focusing on their impact on agriculture and economic development. The research seeks to understand the effectiveness of the implemented strategies, such as water transfers, construction of dams, seawater desalination, and utilization of desert water, in optimizing water resources and improving water availability.

Data on the agricultural sector was gathered by agents of the Subdivisions of the Directorate of Agricultural services, through direct interviews with farmers across 18 agricultural districts in Setif province during the period of 2011–2021. After that, the data was regrouped at the Statistics Office of the same Directorate.

For the water sector, during the period 2017–2021, interviews were undertaken with executives from the Directorate of Agricultural Interests, the Directorate of Algerian Water company (ADE), and the Directorate of Water Resources of Setif Province.

**Results and discussion.** Water Resource Management on Setif Province will be presented in this section.

1. **Introducing the province of Setif.** Setif province is situated in the northeastern region of Algeria. It located in a semi-arid region, experiences an average annual precipitation of less than 400 mm (Bouznad et al., 2020). It is considered the second economic province and the capital of commerce in Algeria. It stands on industrial, service, commercial, and agricultural activities. Its area is estimated at 6,504 km², while the area of the agricultural land is estimated at 67,400 hectares, of which 36,500 hectares are arable (Algerian Ministry …, 2022). It is divided into 18 peasant districts. The topographical structure of the state includes: Northern Mountains Zone: 31.33 %, Southern Mountains Zone: 7.98 %, Agropastoral zone: 28.56 %, Piedmonts: 12.10 %, Plains: 20.03 % (Algerian Ministry …, 2017).

Setif has an area estimated at 36,500 hectares of agricultural land, distributed as follows: more than 20,000 hectares in the eastern region (Elma sector), and 15,800 hectares in the western part of the Setif Hills sector, in partnership with Bordj Bou Arreridj province (10,300 hectares in Setif and 5,500 hectares in Bordj Bou Arreridj) (Algerian Ministry …, 2022).

2. **Great transfers in Setif province.** The province holds two large dam projects that have been completed to circulate water from the neighboring regions to the province of Setif, in addition to the completion of a series of wells in order to fully provide water for various purposes, for the needs of the agricultural sector (Algerian Ministry …, 2015). Through these projects, the state will be able to provide water to water 76,959 hectares of agricultural land (Algerian Ministry …, 2022), so that 46,959 hectares are watered, of which 27,680 hectares are irrigated by standing on 2,558 boreholes, and the remaining 19,279 hectares are irrigated through 5,814 wells and 05 water tanks. These transfers will also provide water in the future to irrigate about 300,000 additional hectares (Algerian Ministry …, 2022).

It should be noted that the water of the Ain Zada Dam will be allocated for watering only, not drinking, since the water quality of the Al-Mawan and Dra’ Al-Dis
dams is more suitable for drinking purposes.

In addition to the previous transfers, there is another small transfer under consideration in the northwestern region of the province, known as the Tishi Haf transfer, which aims to supply each of the municipalities of Bani Warthilan, Bani Mohali, Bou Salam, Bani Shabana, Bougaa, Harbil, Hammam Guergour, and Ain Lagradj. In the southern borders of the province of Setif with the province of M’tila, exactly in the municipality of Soubla (Maqra), there is another dam, also under consideration, that aims to provide water to the municipalities situated in the south of the province.

The following are the most important projects related to water diversion at the state level (Figure 1).

Figure 1. Map of dams in Setif province

Source: created by the authors.

2.1. First project: water transfer from the eastern side (Draa El-Dis Reservoir dam). The transfer of water from the eastern side is undertaken by pumping water from the Iraqn Dam situated in the northeast of Jijel Province to the Dra’ El Dis Dam located near the Eulma district in Setif Province, moving through the Tabellout Dam (a dam
with a capacity of 214 million m³) through a series of steel channels for a distance of 60 km with the help of five pumping stations, where 189 million m³ of water are pumped (Jouve et al., 2022) to provide water to 15 municipalities (153 million m³ for agricultural watering annually and 36 million m³ for drinking), at level of 420 thousand m³/day, enough to irrigate 20,000 hectares of agricultural land (Algerian Ministry…, 2022). It also provides 190,000 m³/day of potable water, enough for the annual needs of 750,000 citizens. The primary purpose of this project is agricultural irrigation. Several channels, typically plastic ones, are relied upon to move water from the dam to the farmers.

There are connecting channels between Dra’ Al-Dis dam and Al-Mawan dam, that allow for the circulation of water in case of any shortage or any defect in one of the dams, with a capacity transfer of 313 million m³/year.

2.2. Second project: water transfer in the center (Al-Mawan Reservoir Dam). The normal capacity of the Al-Mawan Dam reaches 122 million cubic meters, and it can also absorb 148 million cubic meters at maximum capacity, as the rainwater of the region alone contributes 07 million cubic meters absent the use of water transfer. This project transfers water from the Ighil Emda Dam in Kharrata in Bejaia province to the Al-Mawan Dam in Setif province, through steel channels and with the help of three pumping stations (with a total capacity estimated at 67.5 megawatts) for a distance of 22.5 km (Group SGI Consulting, 2022). Al-Mawan Dam is used for drinking and irrigation, as its absorptive capacity is divided into 3 parts, one-third for drinking, and two-thirds for irrigation, which may be enough to water 70,000 hectares using various methods (spraying, dripping...), with the aim of providing water to 13 municipalities, equivalent to 88 million m³ of water for irrigation at a level of 241 thousand m³/day (Algerian Ministry …, 2022). It also provides 56 million m³ of potable water at a rate of 153 m³/day to cover the needs of one million citizens annually.

Even though the water that comes from the dam is raw water, it can also be used for irrigation. To ensure a good quality of water flowing into the dams, the national sanitation office (ONA) filters the valley’s water that flows into the dams and does not leave it in its polluted state (Gharzouli, 2014).

For irrigation, the water moves through a group of stations, adductors then distributors, where each farmer is provided with a tap. Then, the suitable price and economic rate is approved by the National Office of Irrigation and Drainage according to: the quantity of water, the level of demand, and the nature of agricultural activity; for Each plant has a specific amount of water that differs from the other. Henceforth, the method of irrigation is determined, whether by sprinkling or by drip, because traditional irrigation methods would affect the efficiency of the dams.

2.3. Third project: water transfer from the western side (Tichy-Haf Dam). This project depends on the transfer of water from the Bejaia province towards Tichy-Haf dam to cover 06 municipalities in the north of Setif province (Bani Ourthelane, Beni Chebana, Ain Laghrag, Beni Mouhali, Harbil and Qanzat), with a capacity of 81 million m³. It has 10 pumping stations and 6 reservoirs with a total capacity
estimated at 44,000 m$^3$. The primary purpose of this dam is to provide potable water. The region is not agricultural, due to the mountainous nature of the terrain (in comparison to the province’s south), and also because drilling wells is not possible due to groundwater scarcity and the high cost of drilling wells.

2.4. Fourth project: water transfer from the southern side (Chaaba El Hamra and Kharzet Yusuf wells). This project is based on transferring potable water from the wells that were drilled in Al-Chaaba El Hamra and Kharzet Yusuf to the southern regions of the province.

- Chaaba El Hamra transfer. Located in Ain Azal district, it stands on transferring water to 07 municipalities in the southeastern region. These municipalities are Ain Azal, Ain Lahjar, Bayda-Borj, Al-Tallah, Hammam Al-Sukhna, Al-Taya, Al-Walaja. It should be noted that this is joined to the Draa Diss dam.

- Kharzet Yusuf transfer. Depends on moving water to 08 municipalities in the southwestern region. These municipalities are Saleh Bey, Al-Rasfa, Boutaleb, Al-Hamma, Awlad Si Ahmed, Ain Welman, Qasr Al-Abtal, and Bir Hadada.

3. Importance of Transfers. These transfers increase the daily allocation of potable water for residents in this region (200 L/Day/Habitant), and also help to improve the economic and social conditions by:

- Establishing small (industrial and commercial) complexes to provide farmers with the elements of agricultural production, storage, marketing, and transformation of agricultural products, which allows to providing food security for the region.

- Creating approximately 100,000 jobs, including 36,000 permanent jobs, especially in the agricultural field, and also decreasing rural displacement.

- Improving farmers’ incomes by increasing agricultural opportunities in this region. This can be achieved through these transfers which would provide farmers with the sufficient quantity of water for this purpose. The following figure demonstrates the expansion of irrigated land.

![Figure 2. Area of irrigated land during the period 2011–2019, hectares](Source: calculated by the author.)
The number of agricultural foundations in the province achieved 519 collective exploitation establishments (EAC) and 947 individual exploitation establishments (EAI), in addition to 07 model farms, and 40,842 workers are active in the sector, for both the agricultural activity or animal husbandry (Algerian Ministry…., 2017).

Agricultural yield increased greatly due to the availability of water for several types of crops. As seen in Table 1, the percentage increase was notable after completing water transfers for each type of crop.

### Table 1

<table>
<thead>
<tr>
<th>Product</th>
<th>Production per hectare</th>
<th>Growth rate, %</th>
</tr>
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<tbody>
<tr>
<td>Cereals</td>
<td>2,711,150</td>
<td>50</td>
</tr>
<tr>
<td>Dried vegetables</td>
<td>7,126</td>
<td>54</td>
</tr>
<tr>
<td>Gardening</td>
<td>2,146,897</td>
<td>106</td>
</tr>
<tr>
<td>Potatoes</td>
<td>663,087</td>
<td>66</td>
</tr>
<tr>
<td>Fruits</td>
<td>540,871</td>
<td>44</td>
</tr>
<tr>
<td>Milk (10L$^3$)</td>
<td>277,162</td>
<td>49</td>
</tr>
<tr>
<td>Red meat</td>
<td>224,491</td>
<td>4</td>
</tr>
<tr>
<td>Honey</td>
<td>2,480</td>
<td>41</td>
</tr>
<tr>
<td>fodder crops</td>
<td>1,535,810</td>
<td>76</td>
</tr>
</tbody>
</table>

Source: Algerian Ministry of Agriculture and Rural Development, Directorate of Agricultural Services of Setif province.

Additionally, the products that had seen the greatest gains were in horticulture, as they require a significant quantity of water as given the nature of the plant. Although all products achieved increased production, agricultural products outpaced the others.

4. Irrigation Techniques and Farmers Culture. Although the annual rainfall level is acceptable, the problem lies its irregularity throughout the year. This scarcity of precipitation in periods when agricultural crops need rain water, explains why it is necessary to resort to more modern irrigation techniques that does not depend on regular rainwater activity. However, the effectiveness of any program is dependent on the farmers’ understanding and acceptance of modern technologies that aim to better rationalize the problem and make best use of water and irrigation practices.

In order to evaluate these achievements, it is necessary to raise the level of farmers’ consciousness about the importance of rational exploitation of water resources, away from traditional irrigation methods.

What we have seen, unfortunately, is that the majority of farmers still resort to traditional technique of watering. This is more often seen in illegal drilling practices (drilling of unauthorized water sources). These practices affect the levels and sustainability of water layers as well as the revenues of some agencies such as the ONID which are affected due to the use of illegal methods by farmers to obtain water and by fraud in determining the quantity of water consumed and recorded (water meter recordings).

In ordinary cases, upon obtaining an exploration license from the legal authority
(directorate of Water Resources) and the completion of the well, a water meter is set to
determine the level of water consumed (not exceeding the permissible limit) while at
the same time paying a royalty for the water exploitation. However, some farmers
avoid using these legal channels and often resort to illegal methods of unattended
drilling to avoid royalties and roofing the allowed levels of exploited water, even if this
process affects the water layer and its flow.

The water of the valleys is also tapped into for irrigation, even if it is not
appropriate for this use. The problem lies in that it contains untreated chemical residues
resulting from the activities of industry and agriculture (e.g., pesticides), which may be
harmful to public health. The main reason why farmers resort to such traditional
irrigation techniques is due to its low cost.

Conversely, there are irrigation techniques more efficient that are within the reach
of different groups of farmers, especially with the presence of government financial
support for the agricultural sector, among them are axial spraying and dripping, which
contribute to the rational and optimal utilization of water. The motto used is: Don’t
waste, even if you are on a running river.

Due to heavy losses in the past years that have hurt farmers, due to their reliance
on rainwater only for irrigation, they are now more than ever interested in irrigation
methods and sources in order to maximize its production. Therefore, the National
Office of Irrigation and Drainage, in cooperation with the Directorate of Agricultural
Services and the Chamber of Agriculture, seeks to raise farmers’ awareness of the
proper techniques of watering, such as irrigation periods, suitable technologies used,
and the quantity required for each type of crop.

5. Preserving water quality. A new directorate of the national sanitation office
(ONA) and 05 stations have been founded to filter waste water for use in agricultural
irrigation and aquaculture processes. These stations cover 17 municipalities. However,
the rest of the municipalities must use their own equipment.

It is worth noting that residents of Setif Province understand that the quality of
the water distributed to the taps is unpalatable. The water is deemed undrinkable,
due to its foul smell and undesirable taste; it’s mainly used for washing.

Before any dam is realized, water sources like rain and valleys must be taken into
consideration. However, for Ain Zada Dam, source of water for the town of Setif, it is
allowed by three 03 valleys (which two are major: Jari valley and BuSalam valley, and
another is subsidiary: Al-Kharwa valley). BuSalam valley water is negatively affected
by wastewater originating from the industrial zone situated in the valley stream.

The legal component, prior to factories being built is an intense study of
environmental impact(s) on water sources. As said, a water purification station should
be built inside the factory to ensure that water waste has been treated and becomes
clean before being poured into the valleys. Prior to these new laws on environmental
protections, it should be noted that there were many factories built. Of course, the
filtration station of the national sanitation office cannot treat all types of industrial
waste, which makes its way to the dam’s water and then is distributed again for
drinking or irrigation.

Some industrial waste contains compounds with a considerable molecular weight, and will be deposited over time at the dam soil. As summer temperatures rise and the dam’s water level drops, farmers resort to agriculture on the banks of the dam without knowing that the soil is polluted, which negatively influences the quality of crops. Perhaps the most important crop harvested near the banks of Ain Zada Dam is melon fruit, which is planted and irrigated with the water of the dam.

Even farming on the banks of dams affects water quality, because farmers utilize fertilizers that penetrate the dam’s water in the winter after the dam’s water levels rise.

The National Agency for Dams and transfers (ANBT) carry out a periodic analysis of water, but farmers do not declare all the fertilizers used. In addition, there are certain fertilizers that do not list all the ingredients included in the fertilizer, some of which are dangerous to water quality. In addition, these substances are not included in the list of substances included in the detection process carried out by The National Agency for Dams and transfers (ANBT). Since these substances are not on the ANBT, these waters are transferred to water locations intended for drinking or agriculture.

6. Groundwater and exploitation of wells. Setif province is currently initiating a new era of greater exploitation of groundwater. Before 2002, it was merely exploited randomly, especially with regard to irrigation. After the drought crisis in 2002, several citizens better understood the value of water, and even the state provided greater importance to this vital resource.

Regarding the southern side, this province has a good layer of groundwater, where water can be found at a depth of 70 to 100 meters. Due to the fact that the water level on the northern side is relatively low, the depth of digging required to reach water may approach 200 meters.

The majority of drilling projects are concentrated in the southern region of the state, especially in the Ain Azal district, as mentioned in the 4th project (southern transfers), where most of the wells were discovered in this zone due to the activity of the mines (digging in quarries, etc.).

The process of exploiting these resources has legal protections to best preserve the levels of water layers. A groundwater exploitation license must be completed prior to initiating any drilling. The license determines the permissible flow level according to each area, and farmers must pay a royalty for exploitation of the groundwater.

For the northern side of the region, drilling is usually done to exploit groundwater without a license, given the rocky nature of the region, which increases the costs of drilling for farmers on the one side, and the weakness of agriculture due to the roughness of the terrain on the other side. To lower the costs for farmers, the exploitation of groundwater is free without a royalty.

Conclusion. The Setif province has benefited from several projects within the national water strategy. These projects are the three major water diversions in the north, as well as the series of wells south. These projects have increased the amount of land that can be irrigated which has been accompanied by a significant increase in
agricultural production. However, these achievements are contingent on the efficiency of water exploitation by farmers, so the biggest challenge being faced is how to raise the farmers’ conscience about rationalizing water use, in addition to following up on leaks that deplete the province’s water resources.

One of the proposed methods is the Binding Communication thereby raising individual awareness about environmental issues. Such methods can be put into place to raise farmers’ awareness regarding rationalizing water use and adopting more effective technologies for consuming this resource.

Future research prospects. Building upon the findings of this study, further research could explore the long-term sustainability of water resource management strategies in Setif province and other regions of Algeria. Comparative analyses of different water management approaches, including the integration of advanced technologies and innovative practices, could provide valuable insights for policymakers and stakeholders. Additionally, investigating the socio-economic implications of water resource management on rural communities and the agricultural sector could help identify potential areas for improvement. Future studies may also examine the effectiveness of educational and awareness campaigns in promoting responsible water usage among farmers and the general population. Lastly, research on the environmental impacts of water resource management, such as the effects on local ecosystems and biodiversity, would contribute to a more comprehensive understanding of the challenges and opportunities in this field.

References


