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ANALYSIS OF WATER PRICING AND COST RECOVERY IN THE IRRIGATION PERIMETERS OF MITIDJA, ALGERIA

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ABSTRACT

The analysis of irrigation water distribution in the Mitidja perimeter of Algeria reveals significant dysfunctions in the management of resources during periods of scarcity. Despite the distribution network's capacity to respond to demand, the scarcity of resources compels managers to implement a "water rotation" system, overseen by operational agents. The prolonged drought of the last two decades has resulted in the necessity of implementing a rationing system, whereby only the minimum amount of water required for the survival of perennial crops is allocated. Executive Decree No. 05-14, enacted on January 9, 2005, establishes the tariffs for agricultural water use within the irrigated perimeters. The volumetric tariff is set at 2.50 DA/m³, while the fixed tariff is set at 250 and 400 DA per l/s/ha for the Mitidja. However, the aforementioned tariffs, which have remained static since 2005, fail to account for the operational costs associated with the system. The costs of water production have exhibited considerable volatility, with an average of 17.67 DA/m³ between 2014 and 2016. This figure far exceeds the tariffs applied to farmers. The revenue generated from water sales is inadequate to cover the costs incurred, with the proportion of revenue covering costs standing at 19.65%, 24.96%, and 12.75% in 2014, 2015, and 2016, respectively. This situation is further compounded by the presence of aging infrastructure and inadequate pricing. It is imperative that a review of the tariff structure be conducted; taking into account the ability of farmers to pay and including targeted subsidies. Furthermore, operational enhancements and more effective resource administration are essential to guarantee the viability and sustainability of irrigation systems, thereby ensuring sustainable agricultural development.

Keywords: *Irrigation water pricing, water resource management, agricultural sustainability, Mitidja perimeter, Algeria.*

INTRODUCTION

In response to mounting challenges associated with urbanization, population growth, food security, and the effects of climate change, Algeria has adopted a policy for the management of its water resources. One of the objectives of this policy is to promote the efficient use of available water resources among farmers. The studies on subsidy programs for irrigation water savings in Algeria is based on the widely held assumption that subsidies for the development of efficient irrigation technologies lead to water savings. However, while these subsidies generally contribute to greater efficiency and better economic valuation of the water used, the actual water savings have not been fully demonstrated in several observed case studies (Belaidi, Chehat, & Benmehaia, 2022; Belaidi, 2023; Belaidi & Benmehaia, 2023, 2024). Since the implementation of the structural adjustment plan, the country has adopted a cost recovery policy for the operation and maintenance of irrigation water supply systems. This involves the introduction of pricing mechanisms designed to control demand and cover the expenses related to the operation of irrigation and drainage infrastructure. However, despite the 2005 decrees that set the modalities for agricultural water pricing, the applied tariffs remain below the actual operational costs, covering only a fraction of these costs. Executive Decrees No. 05-14 of January 9, 2005 and No. 07- 270 of September 2007 introduced an increase in agricultural water tariffs. However, the revenue generated from these tariffs has not yet reached a level that can be considered sufficient to bridge the gap between costs and generated income. Analyses indicate that the prevailing tariffs cover only 35% of operational costs on average, with the situation becoming particularly critical during drought years. Furthermore, the price of irrigation water is considerably lower than that of potable or industrial water, thereby exacerbating the financial challenges faced by the management bodies of irrigated perimeters. In light of the aforementioned considerations, the central research question is thus: What is the effect of increased agricultural water tariffs on demand management and the coverage of actual water costs in Algeria? The question thus arises as to whether these prices are sufficient to cover the costs of water production. The objective of this study is to evaluate the economic and operational implications of the current pricing policies and to propose recommendations for improvements to the financial sustainability of irrigation infrastructure. The aim is to ensure that the needs of farmers are met while optimizing the management of water resources.

MATERIALS AND METHODS

In order to address the research questions that have been posed, a comprehensive data set has been collected on a number of key aspects. These include the pricing of agricultural water within irrigated perimeters, the evolution of irrigation water prices in the Mitidja West perimeter, the volumes of irrigation water distributed to the irrigated area within the perimeter, and the cost per cubic meter of water along with the cost recovery mechanisms that are in place. The data were obtained from the ONID irrigation agency through the analysis of annual operation and maintenance reports, annual financial statements (2014-2016), and irrigation records (1988-2016). Furthermore, for the purposes of this analysis, we have also drawn upon technical reports from ONID on the subject of hydroagricultural management and the agricultural development of the Mitidja region. Furthermore, an extensive literature review was conducted to enhance the study by incorporating existing research and studies from other countries, thereby enabling a comparative analysis of cost recovery methods on an international scale. Furthermore, our research is informed by a field survey conducted throughout 2020, which illuminates the perception of agricultural water prices among farmers within the Algerian context. The survey illuminates the challenges and contradictions encountered by Algeria in the management of its water resources for agricultural purposes, offering invaluable insights into the intricate complexities of water resource management in the region.

Description of the Study Area

The irrigation schemes selected for this study include East Mitidja, West Mitidja Phase I, West Mitidja Phase II, and Sahel Algérois, located in the most fertile region of northern Algeria. East Mitidja and West Mitidja Phase I cover agricultural areas of 18,000 hectares and 9,250 hectares, respectively. Farmers within these schemes are categorized into three groups: collective state farms, individual state farms, and private farms. Surface irrigation water for East Mitidja is supplied by the Hamiz Dam, Reghaia Marsh, and Boureah Pumping Station, with a total theoretical storage capacity of 33 million cubic meters. West Mitidja Phase I is served by the El-Moustaqbal Dam, which has a total theoretical storage capacity of 188 million cubic meters. West Mitidja Phase II began operations in 2004 and spans 15,600 hectares, divided between Tipaza Province (14,400 hectares) and Blida Province (1,200 hectares). The Sahel Algérois scheme, located in Tipaza Province, commenced operations in 2005 and covers 2,888 hectares. The primary crops in these schemes include various orchards and a range of annual crops.

The management, operation, and maintenance of thse perimeters were previously handled by the Office des Périmètres d’Irrigation de la Mitidja (O.P.I.M.), established by decree no. 85-262 on October 29, 1985. This responsibility continued until 2005, when the regional Offices of Irrigated Perimeters were dissolved following the reorganization of A.G.I.D. into O.N.I.D (National Office of Irrigation and Drainage). Subsequently, these duties were transferred to the operational unit of the regional directorate under the supervision of O.N.I.D.

WATER PRICING: ECONOMIC PRINCIPLES AND COST RECOVERY

"From a microeconomic perspective, prices allocate resources efficiently based on their value in alternative uses. Environmental economics views prices as incentives to change consumer and operator behavior according to environmental policy goals. In management sciences, prices are a revenue source that helps operators cover costs and earn a fair profit. From a public finance perspective, prices can finance public services and infrastructure as an alternative to the general budget" (Massarutto, A., 2007). From an economic standpoint, marginal cost pricing represents a fundamental tenet for achieving optimal resource allocation. This approach entails establishing water prices at a level commensurate with the cost of producing an additional unit of water, thereby ensuring that marginal benefits and costs are aligned. This method ensures efficiency and Pareto optimality (Decaluwé, Patry, and Savard, 1998). Nevertheless, in instances where marginal cost pricing yields prices below the average total cost of production, the necessity arises for government subsidies to bridge the gap and ensure the continued efficiency of resource allocation.

An alternative approach, known as Ramsey-Boiteux pricing, addresses this issue by setting prices above marginal cost, thereby obviating the necessity for subsidies. This method serves to minimise deviations from Pareto optimality through the application of a markup based on the inverse elasticity rule proposed by Frank Plumpton Ramsey (Ramsey, 1927). The objective of Ramsey pricing is to maximize consumer surplus while maintaining a zero profit margin. This requires the implementation of differentiated pricing strategies for various user groups, based on their responsiveness to price fluctuations. Accordingly, the markup rate is determined by the price elasticity of demand for disparate user groups (Decaluwé, Patry, and Savard, 1998).

From an economic perspective, pricing is regarded as a principal instrument for the management of resources, particularly within the context of agricultural production. Historically, pricing has been designed with two primary objectives: to cover the costs incurred by managers and to allocate water efficiently. As with any economic good, the supply and demand of water are subject to the laws of economics. In regard to the demand side, the objective is to ascertain the users' willingness to pay, whereas on the supply side, the focus is on estimating production costs. This interaction of supply and demand provides the foundation for pricing strategies.

A significant debate exists regarding the optimal pricing strategy for water: whether to price water based on its marginal cost or its average cost. The concept of full-cost recovery (FCR) for water services, involving charges paid by both users and polluters, is widely seen as a fundamental principle of sustainable water management (Massarutto, A., 2007). International institutions advocate for full-cost recovery (FCR) to secure revenue for water service operators, promote private sector involvement, and enable market financing (Winpenny, 2003).

Pricing is frequently regarded as a means of recovering costs rather than as a tool for managing water demand (Winpenny, 1994). This perception is based on the assumption of inelastic demand. The prevailing view among experts in water policy is that irrigation water tariffs in agriculture are relatively low, covering only a small proportion of the costs incurred by the state (Sghaier, 1995). The low level of cost recovery in agriculture is largely attributed to policymakers' reluctance to raise water tariffs and taxes, coupled with concerns about the financial burden these measures might impose on users (Berbel and Expósito, 2020).

OVERVIEW OF IRRIGATION WATER PRICING IN ALGERIA

The objective of the pricing policy is to guarantee that the managing bodies of irrigated perimeters possess the requisite financial resources to fulfill their obligations to irrigators in accordance with the concession regime established by the state. However, the current pricing structure is designed to cover only operating costs, with differentiated rates according to the irrigation perimeters. In contrast, the pricing of water for agricultural use should cover the costs and expenses associated with maintaining and operating irrigation and drainage infrastructure, as well as

contribute to the financing of investments for their recovery and expansion. The rates have increased from 1.00 to 1.25 to 2.00 to 2.50 DA/m³ between 1996 and 2005, respectively, and are applicable for the supply of water in irrigated perimeters.
As illustrated in Table 1, the water prices applied in other perimeters are as follows: The volumetric price is 2.00 DA per cubic meter of water upstream of the plots, while the fixed price is 250 DA per hectare subscribed. Consequently, any agricultural operator whose lands are situated within an irrigated perimeter is obliged to enter into a contract. The current rates are 2 to 2.50 DA per cubic meter at the plot head, in addition to a fixed rate of 250 to 400 DA per liter/second/hectare subscribed. In fact, the most recent pricing data from 2005 aligns with the conditionalities of the structural adjustment plan negotiated with the International Monetary Fund (IMF). This plan committed Algeria to increase the real water tariff by 10% annually over ten years (1995-2005) for all sectors of use (Salem, 2007). However, since 2005, agricultural water tariffs have remained static, and the levels set by decree have proven inadequate for meeting the conditions for balancing operating costs, particularly in the absence of accounting for investment amortization in irrigated perimeters.

Table 1. Agricultural Water Pricing in Irrigated Perimeters in 1996 and 2005

Irrigated Perimeter	**Province**	**1996**		**2005**	
		Variable Tariff DA/m³	Fixed Tariff DA/l/s/h	Variable Tariff DA/m³	Fixed Tariff DA/l/s/h
Sig	Mascara	1,20	250	2,50	250
Habra		1,20	250	2,50	250
Mina	Relizane	1,00	250	2,00	250
Bas Cheliff	Chlef	1,00	250	2,00	250
Moyen Cheliff	Chlef	1,15	250	2,00	250
Haut Cheliff	Ain Defla	1,25	400	2,50	400
Mitidja Ouest	Blida, Tipaza	1,00	400	2,50	400
Hamiz	Alger, Boumerdès, Blida	1,25	400	2,50	400
Bouchegouf	Guelma	-	-	2,50	400
Saf Saf	Skikda	1,00	400	2,00	400
Bounamoussa	El Tarf — Annaba	1,20	400	2,50	400

Source: Executive Decree No. 05-14, January 9, 2005, JORADP (1996)

Indeed, this pricing has been demonstrably inadequate for the effective management of irrigated perimeters (Benblidia, 2011). The World Bank study (2007) indicates that this new pricing structure does not significantly reduce the gap between revenues and operating and maintenance costs, except in a few cases. The data indicates that the fees collected cover, on average, only approximately 78% of the operating and maintenance expenses associated with the 19 irrigated perimeters under study. The majority of these perimeters (14 out of 19) exhibit a coverage rate that ranges between 32% and 87%. A substantial proportion of the fees is allocated to remunerating the workforce, which has undergone a considerable expansion, leaving a negligible allocation for maintenance expenditures (Benmihoub & Bédrani, 2012). The situation becomes more complex during drought years when the volumes of water sold are sometimes insignificant, while state subsidies, although contractually stipulated, are almost never disbursed to managing organizations (Benmihoub & Bédrani, 2012). The study by Fabre & De Abreu (2018) provides a clear illustration of the issues with the current regulated water pricing (for both irrigation and domestic use). These issues arise from the fact that the pricing structure does not account for the cost of mobilizing raw water at the dam level, upstream of the distribution network. Our analysis of major irrigated perimeters across five regional directorates, based on data from three irrigation campaigns from 2014 to 2016, revealed that the price of irrigation water is below the operational costs of the perimeters.

In some instances, the revenue generated is insufficient to cover even 10% of the total cost, or it may only cover the electricity charges. The mean cost recovery rate for all major irrigated perimeters is 34% or less over the three irrigation campaigns (Belaidi, 2023). As a result, the operational activity has been severely lacking over the past three years across all regional directorates. The revenue generated from water sales exhibits considerable variability from one year to the next. Fluctuations in water resource allocations have an impact on irrigated areas, which in turn affects the aforementioned revenue. The deficit is typically rectified by the state through the provision of balancing subsidies, which serve to offset the discrepancy between the actual operational expenses and the revenue generated from water sales. However, the level of subsidies has been declining over time. Notwithstanding the low tariffs for Irrigated Perimeter Offices (OPI), the irrigated area in Major Irrigated Perimeters (GPI) fails to reach the equipped areas.

Consequently, the revenue generated from water sales remains relatively low, and when considered alongside the limitations imposed by tariffs, this creates a challenging financial situation for the offices. This impedes their capacity to guarantee the functioning and upkeep of irrigation networks, which in turn precipitates the deterioration of equipment. The irrigation water tariff does not appear to provide an incentive for farmers to conserve water, as evidenced by Table 2. The current and projected tariffs set forth in Executive Decree No. 07-270 of September 2007 remain at a very low level and apply exclusively to large public irrigation areas. The tariff structure does not encompass small and medium hydraulic systems. A price revision is currently under consideration, and the implementation of a tax on boreholes is also planned.

Table 2. Water Cost/Water Price (DA per m³)

Networks	**Average Cost**	**Tariff**	***Coverage Rate (Tariff/Cost)***
By gravity	5	2	40%
By pumping	8	2.5	32%

Source: Langenberg et al. (2021)

Farmers do not bear the costs of investment nor the operational and maintenance expenses of the infrastructure used for raw water mobilization. Public authorities do not, in fact, cover a significant portion of the expenses related to the dams that supply large irrigated perimeters. A 2007 study on agricultural water pricing revealed an average national production cost of 5.6 DA/m³, assuming that the ONID (National Office of Irrigation and Drainage) does not incur any charges from the ANBT (National Agency of Dams and Transfers) for the water released (Kherbache, 2014). This pricing adjustment takes into account only operational expenses. The same applies to the increase planned in 2008.

From 2009 onward, investments were to be included in the bills. However, even with these increases, the tariff would not cover the operational costs, which were between 9 and 12 DA/m³ prior to 2005, whereas the average operational cost is around 25.5 DA. With this increase, the average tariff would rise to 20 DA, covering approximately 60% of the operational costs. This study was conducted to adjust the tariffs, but nothing evolved afterward. Currently, it is estimated that only less than 50% of operational costs are covered. However, the most negative impacts are likely seen in the Small and Medium Hydraulics (PMH) sector. The large volumes of water used by the PMH are not billed at present. This results in overexploitation of groundwater resources and significant risks of depletion and salinization of aquifers. The presence of a management body implies more investments, including the construction of canals for water delivery, the establishment of pumping stations and their maintenance costs, energy charges, personnel costs, etc., which undoubtedly makes the cost per cubic meter much higher.

RESULTS AND DISCUSSION

The Price of Irrigation Water

As the primary source of income for the operational units within irrigated perimeters, agricultural water pricing often remains flat-rate. Water meters, which are essential tools for the effectiveness of a water pricing schedule and necessary for estimating the actual volumes of water consumed, are frequently absent. This absence is either due to under-equipment or often intentional damage to the meters. Regrettably, the diagnostic study of the hydraulic infrastructure within irrigated perimeters, initiated in 2004, confirms that most users or subscribers were without meters (Chetibi, 2007). In our study area, no user is equipped with a meter due to deliberate sabotage, resulting in these users being subjected to a flat-rate pricing system. Furthermore, in consumption-based pricing schedules, the unit prices are very symbolic and typically do not exceed 2.5 DZD per cubic meter of water. Nevertheless, the historical data on agricultural water pricing in Algeria reveals that irrigation water tariffs, which remain significantly subsidized by the state, have doubled over the course of a decade, increasing on average from 1.25 to 2.5 DZD between 1995 and 2006, as shown in Table 3 below. Following a 100% increase in 2005, the price per cubic meter has since remained virtually unchanged.

Table 3. The evolution of irrigation water prices in the Western Mitidja area, 1988-2020

Years	1988 - 1992	1993 - 1994	1995 - 1998	1999-2004	2005 - 2024
Prices (DZD/m³)	0.35	0.80	1.00	1.25	2.50

Source: ONID agency

Moreover, the option of using groundwater for irrigation may influence the price elasticity of surface water demand within the perimeter. For many farmers, the availability of groundwater is insufficient to fully irrigate their plots, particularly for water-intensive crops such as citrus fruits and fruit trees. As a result, a significant portion of farmers cannot entirely forego the use of surface water. In our survey, we asked operators the following question: What do you think of the ONID irrigation water price? With the rate of 2.5 DZD per cubic meter applied since 2005, 62.50% of surveyed operators consider the price to be low, while 19.12% believe it is very low.

Table 4. Operators' Perception of ONID Agricultural Water Pricing

Water Price	**(1) Too Expensive**	**(2) Expensive**	**(3) Average**	**(4) Low**	**(5) Very Low**	**Total**
Number of Operators	4.00	8,00	13.00	85.00	26.00	136
Percentage (%)	2.94	5.88	9.56	62.50	19.12	100

*Source: Survey, 2020

After 2005, the situation has not significantly changed: the cost of water still averages only 3.9% of potato production costs in the public perimeter of Arribs (Chibane, 2008, cited in Benmihoub & Bedrani, 2012). Similarly, irrigation costs account for less than 10% of total production costs in the Mitidja (Imache & Belarbia, 2010; Bouarfa et al., 2010). Oulmane (2018) obtained similar results, finding that irrigation costs represented only 2% of production costs in the Taher perimeter (Jijel). The calculation of irrigation water costs within the total expenses for citrus cultivation represents 4% and 8% for surface and groundwater, respectively (Belaidi, 2023). Laoubi (2009) used sensitivity analysis to identify critical inputs in the financial model and their impact on outcomes in the East and West Tr1 irrigated perimeters. This analysis shows that average irrigation costs account for only 5.68% (using water-saving technologies) and 9.43% (using gravity systems). Consequently, revenues are less sensitive to the variable of irrigation cost "water price.

Moreover, the agricultural water tariff appears low relative to its value in agriculture: for instance, greenhouse vegetable cultivation yields a margin of 200 DZD per cubic meter of water compared to 110 DZD/m³ for citrus in the Mitidja (Benouniche et al., 2010). The economic water productivity varies from 10.33 DZD/m³ for tomatoes to 226.78 DZD/m³ for bell peppers under greenhouse conditions. Citrus and peaches in intensive cultivation provide net margins of 83.41 DZD and 135.05 DZD per cubic meter, respectively. The average water productivity value was found to be 64.19 DZD/m³ in the Mitidja-East perimeter (Laoubi, 2009). Furthermore, these low percentages are insufficient to incentivize water conservation.

In other countries (Greece, France, Morocco, etc.), the relative cost of water ranges between 10% and 20% of total production costs for farmers to induce water resource conservation (Laoubi, 2009). In Spain, the recovery of capital and investment (C&I) costs is at 56%, while operation and maintenance (O&M) costs are almost fully recovered, totaling around 85%. This efficiency suggests optimal water infrastructure management. In Portugal, the recovery of C&I costs is lower, at only 23%, although O&M costs are nearly fully recovered, totaling 65%. The low recovery of C&I costs may indicate financial challenges. In France, C&I cost recovery varies between 15% and 60%, showing significant regional disparities, while O&M costs are almost fully recovered, totaling around 85% (Berbel et al., 2019).

Irrigated Areas and Water Volumes Distributed

The perimeter traditionally relied on gravity irrigation from individual wells and boreholes. The state established a public network, supplied by reservoir dams and managed by an Irrigation Perimeters Office (OPI), with the aim of preserving groundwater while supporting the expansion of irrigated agriculture across the plain. However, the water from the public network constitutes only a minor portion of the total water used by irrigators. Due to existing malfunctions, the 8,600 hectares equipped have never seen more than 2,800 hectares effectively irrigated by this network (Messahel & Benhafid, 2007). Consequently, there has been a growing and haphazard exploitation of groundwater, impacting both the sustainability of this resource—which is also used for potable water supply during dry periods—and the capabilities of the Office, which is facing increasing challenges. In this context, farmers adopt various strategies: some rely solely on water from the public network, others prefer individual boreholes, or use mixed solutions (Messahel & Benhafid, 2007).

Of the total equipped area of the study perimeter, which spans 8,600 hectares, the irrigable area is 7,927 hectares and has not changed significantly. Nevertheless, it has seen a slight reduction due to urban expansion and road infrastructure, decreasing to 7,872.43 hectares. By 2016, of these 7,872.43 hectares considered irrigable, only 532.52 hectares were actually irrigated by the public network, accounting for nearly 6.77% of the irrigable area, with a distributed volume of approximately 0.809 Hm³.

The period during which the highest number of new boreholes was drilled was from 1994 to 1998, when the O.P.I.M. was unable to distribute any cubic meters of water to farmers due to a terrorist attack targeting the dam distribution station in 1994.
As illustrated in Figure 1, there was a notable absence of irrigation from 1995 to 1998 due to the security conditions in the Western Mitidja Tr1 perimeter, which led to intentional damage to the dam and intake structures, resulting in the suspension of water releases. Additionally, a zero volume distributed is observed in 2002, when the O.P.I.M. did not provide water to the Western Mitidja perimeter. This was due to an exceptional drought that affected the country that year and an emergency plan implemented by the public authorities, which allocated the water from the Bouroumi dam solely to the potable water supply for Algiers.

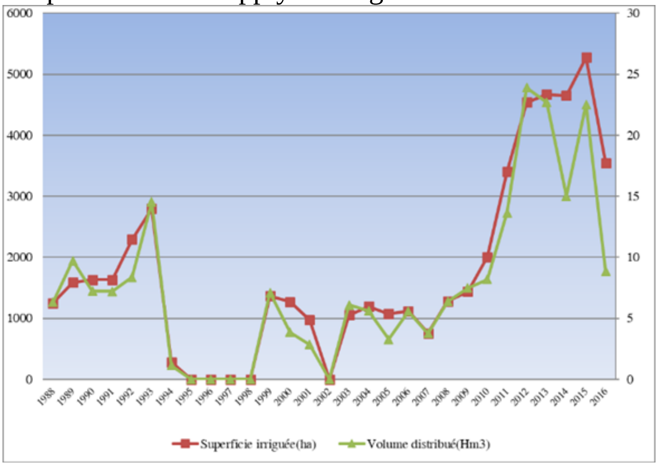

Figure 1. Irrigation Water Volumes Distributed and Irrigated Area in the Western Mitidja Perimeter (Compiled by the author from ONID data)

In general, the curve of distributed water volume follows the curve of irrigated areas. However, a detailed analysis reveals that from 2000 to 2005, irrigated areas decreased despite an increase in the volume of water distributed. For instance, in 2003, with 6.1 Hm^3 of water, 1,056 hectares were irrigated. In 2004, with a reduced water volume of 5.6 Hm^3, a larger area of 1,197 hectares was irrigated. Similarly, with even less water—3.8 Hm^3 in 2000 and 3.2 Hm^3 in 2005—larger areas of 1,270 and 1,075 hectares were irrigated, respectively. This suggests that the irrigated area is not directly proportional to the volume of water distributed, primarily due to variations in irrigation doses, which are reduced during deficit years, particularly to sustain tree crops.
Additionally, there has been a sustained increase in irrigated areas since 2007, but this trend primarily pertains to the Western Mitidja. Since 2004, the two sections of the irrigated perimeter were merged (8,600 hectares for section 1 plus 15,400 hectares for section 2). In reality, irrigated areas in the Western Mitidja remain low relative to the irrigable area; on average, from 2006 to 2016, the irrigated area never exceeded 12% of the irrigable area. Similarly, in the Western Mitidja Tr1, the average irrigated area from 1988 to 2005 never surpassed 10% of the irrigable area.

Financial Situation of the Irrigation Perimeter Offices

Water Cost per Cubic Meter and Cost Recovery in the Perimeter

According to data provided by O.N.I.D, the cost of producing one cubic meter of water in the Mitidja Ouest perimeter was 13.13 DA/m³ in 2014, 10.25 DA/m³ in 2015, and 21.57 DA/m³ in 2016, with an average cost of 17.67 DA/m³ over these three years. The variations in production costs from one irrigation season to another can primarily be attributed to changes in the volume of water distributed. On average, over the three irrigation campaigns, the cost of water distributed is nearly six times higher than the price paid by farmers. In 2016, this discrepancy is even more pronounced, with the production cost being almost nine times greater than the volumetric rate of 2.5 DA/m³ applied. The production cost increased by nearly 50% compared to the 2014 and 2015 irrigation campaigns, due to rising total expenses and decreased water distribution. The revenue collected from water sales is insufficient and fails to cover costs: 19.65%, 24.96%, and 12.75% for the 2014, 2015, and 2016 irrigation campaigns, respectively (Table 23). This situation is due, on one hand, to the low volumes allocated for irrigation and, on the other, to the low agricultural water tariffs applied in these irrigation perimeters. The water distribution infrastructure faces significant long-term degradation risks, as the price paid by users does not cover operational and maintenance costs.

The financial data analysis for the Mitidja Ouest irrigation offices reveals several structural and economic challenges that undermine the viability and sustainability of the irrigation system. The substantial gap between the production cost of water and the rate charged to farmers highlights a critical financial imbalance. This imbalance is exacerbated by fluctuations in production costs, mainly influenced by variations in distributed water volumes, indicating vulnerability to water demand and operational efficiency.

The low cost recovery from water sales, as evidenced by the low percentages of cost recovery in the irrigation campaigns, indicates a structural insufficiency in water pricing. This financial shortfall not only prevents covering operational and maintenance costs but also hinders necessary investments in infrastructure improvement and maintenance. Over time, this situation risks leading to progressive degradation of irrigation infrastructure, compromising the ability of the irrigation perimeters to provide adequate and high-quality water.

It is essential to revise the pricing structure to better reflect the actual production cost of water while considering farmers' payment capacity. Targeted subsidies and financial support mechanisms could be considered to assist farmers in managing revised tariffs while ensuring the financial sustainability of the irrigation offices. Concurrently, efforts should be made to enhance operational efficiency and reduce water losses to maximize resource use and minimize costs. An integrated and multidimensional approach is required to address the financial issues facing irrigation perimeters. This approach should include tariff reforms, improvements in operational efficiency, and financial support policies for farmers. By doing so, it will be possible to ensure sustainable and effective water resource management, securing the long-term viability of irrigation systems and promoting sustainable agricultural development.

Table 5. Cost Recovery Rates in the Mitidja Region

Campaign	Perimeter	Costs (DA)[1]	Irrigated area (ha)	Water Sales (DA)	Difference (DA)	Recovery Rate (%)
2014	Mitidja East (Hamiz)	132.090.000	2343.51	22.650.000	-109.440.000	17.5
	Mitidja West	214.340.000	4652.05	39.380.000	-172.230.000	19.65
	Algerian Sahel		373.70	2.730.000		
	Total	346.430.000	736926	64.760.000	-281.670.000	18.69
2015	Mitidja East (Hamiz)	138.580.000	2254.89	20.150.000	-118.430.000	14.54
	Mitidja West	246.920.000	5274.89	58.400.000	-185.290.000	24.96
	Algerian Sahel		419.95	3.230.000		
	Total	385.500.000	7949.73	81.780.000	-303.720.000	21.21
2016	Mitidja East (Hamiz)	154.930.000	1750.00	20.740.000	-134.190.000	13.39
	Mitidja Ouest	251.910.000	3550.07	6.850.000	-219.790.000	12.75
	Mitidja Center		412.66	23.520.000		
	Algerian Sahel		532.52	1.750.000		
	Total	406.840.000	7040.44	57.020.000	-349.820.000	14.02

*Source: ONID, 2017a, 2017b

The forecasted fee assessment is carried out annually based on a prescribed price. Executive Decree No. 05-14 of January 9, 2005, defines the water pricing modalities for agricultural use and the associated rates. Article 06 specifies the applicable rates for water supply in the Mitidja Ouest irrigation perimeter, setting the volumetric rate at 2.50 DA per m³ and the fixed rate at 400 DA per l/s/ha. This tariff is binary, with the first part paid at subscription, corresponding to 50% of the subscribed water

[1]The costs are the sum of the operational unit costs, regional directorate costs, and the costs of the General Directorate.

volume price, and the second part paid at the end of the irrigation campaign, based on the actual volume consumed.

Since independence, the established tariffs have never accounted for the specifics of each perimeter, maintenance and operational costs, major repairs, or infrastructure investments. This pricing was symbolic and subsidized by the state. Moreover, the irrigation water tariff set by the management structure is considered affordable and reasonable by many users surveyed, remaining less costly than groundwater exploitation through boreholes, provided the dam water availability is continuous. However, the lack of trust in the water management structure has made users hesitant to invest in a resource whose availability is not guaranteed during dry periods, jeopardizing their investments, especially in arboriculture. Despite a trend of rising tariffs over time, the current pricing remains attractive to farmers. However, in Mitidja-Ouest, due to the forfait tariff system and the uncertainty surrounding the volumes of water distributed by the irrigation office—both in terms of quantities and the irregularity of water turns within the same irrigation campaign—farmers prefer groundwater.

From an economic analysis perspective, three types of instruments can be employed in water management: pricing, quotas, and water markets. According to Montginoul (1997), these instruments do not all achieve the same objectives. Pricing aims at efficiency, equity, or budget balance depending on the approach adopted. Montginoul (1997) identifies two types of pricing: incentive pricing, which encourages farmers to conserve water without penalizing their income, and dissuasive pricing, which penalizes farmers for exceeding a certain water volume, impacting their income. Dissuasive pricing is not feasible for Mitidja, given the current water volumes are insufficient to irrigate the equipped area and farmers can turn to groundwater. In Mitidja Ouest Tr1, the goal of the low current pricing (2.5 DA/m^3) was equity and increased agricultural production.

CONCLUSION

Water pricing is widely recognized as a crucial tool for achieving water sustainability. Official reports on the water supply sector often prioritize physical and financial progress over the quality, reliability, and sustainability of water services. This focus has led to significant inefficiencies in large-scale irrigation perimeters, resulting in poor service quality and high levels of water losses. The sector is characterized by a low-level equilibrium where inadequate service and minimal accountability from water utility services lead to a low willingness to pay among consumers. This situation, in turn, creates a financial crisis for public utilities, making it challenging to improve maintenance and daily operations. An analysis of the financial situation of irrigation offices, particularly in the Mitidja Ouest area, reveals substantial structural and economic challenges that threaten the viability and sustainability of irrigation systems. The disparity between the cost of water production and the tariffs charged to farmers, coupled with low cost recovery through water sales, highlights a critical financial insufficiency. This issue is compounded by fluctuations in production costs, driven by the volume of water distributed, indicating vulnerability to water demand and operational efficiency. To address these issues, it is essential to revise the water pricing structure to more accurately reflect actual costs while considering the farmers' ability to pay. Targeted subsidies and financial support mechanisms should be considered to mitigate the impact of revised tariffs on agricultural operators. Concurrently, operational improvements are necessary to enhance efficiency and reduce water losses, thereby optimizing resource use and minimizing costs. An integrated and multidimensional approach, including tariff reforms, operational improvements, and financial support policies, is crucial for ensuring the sustainable and effective management of water resources. By adopting such an approach, it will be possible to ensure the longevity of irrigation systems while promoting sustainable agricultural development that is resilient to economic, social, and environmental challenges

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