

Rethinking Agricultural Water Pricing in Algeria under Conditions of Water Scarcity: A Comparative Policy Analysis

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Abstract:

This study critically assesses Algeria's agricultural water pricing policy as an economic instrument for managing water demand under increasing water scarcity. Using a descriptive–analytical and comparative policy approach, it evaluates national tariff regulations, financial performance indicators, and institutional irrigation practices, and benchmarks them against selected regional and international experiences. The results show that irrigation tariffs remain highly subsidized and largely uniform, with limited differentiation by water source, scarcity level, or crop value, weakening scarcity signals and limiting cost recovery. Comparative evidence indicates that pricing reforms, combined with technological modernization, regulatory oversight, and targeted farmer support, can improve efficiency and sustainability. The study recommends a gradual, equity-based reform pathway to strengthen water and food security resilience in Algeria.

Keywords: Water Scarcity; Agricultural Water Pricing; Food Security; Water Policy Reform; Comparative Policy Analysis; Algeria.

Jel Classification Codes : Q11 ; Q18 ; Q25.

Résumé:

Cette étude évalue de manière critique la politique de tarification de l'eau agricole en Algérie en tant qu'instrument économique de gestion de la demande en eau dans un contexte de rareté croissante. À l'aide d'une approche descriptive–analytique et comparative, elle analyse les réglementations tarifaires nationales, les indicateurs de performance financière et les pratiques institutionnelles d'irrigation, en les comparant à des expériences régionales et internationales sélectionnées. Les résultats montrent que les tarifs d'irrigation restent fortement subventionnés et largement uniformes, avec une faible différenciation selon la source, la rareté ou la valeur des cultures, ce qui affaiblit les signaux de rareté et limite la récupération des coûts. L'étude recommande une réforme progressive fondée sur l'équité pour renforcer la résilience hydrique et alimentaire.

Mots clés: Rareté de l'eau; tarification de l'eau agricole; sécurité alimentaire; réforme de la politique de l'eau; analyse comparative des politiques; Algérie.

Jel Classification Codes : Q11 ; Q18 ; Q25.

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I. Introduction

Water scarcity has become a defining structural constraint for economic development in arid and semi-arid regions. Algeria is characterized by limited renewable freshwater resources, high climatic variability, and increasing demographic pressure. According to FAO AQUASTAT, total renewable water resources (TRWR) amount to approximately 11.67 km³ per year, while total water withdrawals reached 10.96 km³ in 2022 (FAO, 2025). Agriculture accounts for the largest share of withdrawals (7.39 km³), followed by municipal and industrial uses. The reported SDG 6.4.2 water stress indicator exceeded 100 percent in 2022, reflecting severe pressure on renewable resources and increasing reliance on groundwater abstraction (FAO, 2025).

Under such conditions, irrigation policy occupies a central position in scarcity management. While Algeria has historically relied on supply-oriented measures—such as dam construction, groundwater development, and more recently desalination expansion—projected population growth and climate change intensify the need for demand-side instruments. Population projections indicate continued growth toward mid-century, which will mechanically reduce per capita renewable water availability if total resources remain constant (PRB, 2024). Consequently, improving water-use efficiency in agriculture is essential for sustaining food production and rural livelihoods.

Economic theory recognizes water as both a social and economic good, implying that pricing can serve as a demand-management instrument when appropriately designed (Rogers et al., 2002; Savenije & Van Der Zaag, 2002). In irrigation systems, tariffs are expected to transmit scarcity signals, promote allocative efficiency, and contribute to financial sustainability through cost recovery. However, in many water-scarce economies, irrigation pricing remains heavily subsidized and weakly differentiated, reducing its effectiveness as an economic instrument (Molle & Berkoff, 2007).

In Algeria, the agricultural water pricing framework is governed primarily by Executive Decree No. 05-14, which defines tariff modalities and service structures. Despite the existence of a formal pricing system, concerns persist regarding low tariff levels, limited differentiation across water sources, and partial cost recovery. Existing studies focus either on farm-level behavioral responses (Oulmane et al., 2019) or broader water governance issues, without systematically linking tariff design, scarcity conditions, and long-term irrigation sustainability.

I.1 Research gap: This constitutes a significant research gap, as the interaction between tariff structure, scarcity signaling, and cost recovery performance in the Algerian context has not been comprehensively analyzed. Furthermore, empirical benchmarking of the Algerian framework against comparable regional experiences—particularly from Maghreb and other water-scarce economies—remains limited in the existing literature.

This study addresses this research gap by evaluating Algeria's agricultural water pricing policy through an integrated scarcity–sustainability lens.

I.2 Research Problem: Despite the existence of a formal water pricing framework under Executive Decree No. 05-14, Algeria's agricultural tariff structure has received limited integrated evaluation. The central research problem addressed by this study is: **To what extent does Algeria's agricultural water pricing framework function as an effective instrument for managing irrigation demand and ensuring the financial sustainability of water services under conditions of structural water scarcity?.**

I.3 Research Hypotheses: The study is guided by two interrelated hypotheses:

H1: Algeria's largely uniform and heavily subsidized tariff structure is insufficient to transmit meaningful scarcity signals to irrigators, thereby limiting its capacity to promote water-use efficiency or guide allocative decisions.

H2: The prevailing tariff levels generate insufficient revenue to cover the operation and maintenance costs of public irrigation infrastructure, perpetuating a structural cost-recovery deficit and compromising the long-term financial sustainability of irrigation services.

I.4 Significance of the Study: This study is significant on both academic and policy grounds. Academically, it contributes an integrated scarcity–sustainability evaluation of Algeria's tariff framework, a dimension that has received limited attention in the existing literature. From a policy perspective, the findings are directly relevant to Algeria's ongoing water governance reform agenda and provide a comparative evidence base for countries in the Maghreb and broader MENA region facing similar challenges of water scarcity, subsidy dependency, and irrigation infrastructure sustainability.

I.5 Research Objectives: To address the research problem and test the above hypotheses, the study pursues the following specific objectives:

- To assess Algeria's structural water-stress context using internationally harmonized macro-level scarcity indicators.
- To analyze the design features and cost-recovery performance of existing agricultural water tariffs, with reference to Executive Decree No. 05-14.

- To benchmark the Algerian system against selected regional (Maghreb) and international irrigation pricing experiences, and to derive evidence-based policy reform pathways applicable to Algeria's context.

I.6 Paper Organization: The remainder of the paper is organized as follows: Section II presents the theoretical background and literature review; Section III describes the research design and methodology; Section IV presents the empirical results; Section V discusses the findings in light of comparative evidence; and Section VI offers conclusions and policy recommendations.

II. Theoretical Background and Literature Review

Before reviewing the literature, it is useful to clarify the two central concepts employed in this study. Agricultural water pricing refers to the system of charges applied to irrigation water use, encompassing volumetric tariffs, fixed subscription fees, and differentiated rate structures. Pricing mechanisms are intended to serve multiple objectives simultaneously: generating revenue to cover service costs, allocating water to higher-value uses, and transmitting signals of resource scarcity to users (Johansson et al., 2002).

Cost recovery, in turn, refers to the extent to which tariff revenues cover the operation and maintenance (O&M) costs of irrigation infrastructure and service delivery. Full cost recovery implies that tariff income is sufficient to finance routine maintenance, infrastructure rehabilitation, and administrative overhead without recourse to external public transfers. Partial cost recovery, by contrast, implies ongoing reliance on budgetary subsidies to maintain service levels (Easter & Liu, 2005; Molle, 2009).

The economic rationale for water pricing is grounded in the principle that scarce resources require efficient allocation mechanisms. When water is underpriced relative to its scarcity value, consumption may exceed socially optimal levels, leading to resource depletion and fiscal burdens. Pricing mechanisms aim to align private incentives with social objectives by incorporating at least part of the opportunity cost of water (Rogers et al., 2002).

However, irrigation water pricing operates within a second-best environment. Measurement constraints, political sensitivity, and food-security considerations often limit the ability to implement full marginal-cost pricing. As noted by Molle and Berkoff (2007), irrigation pricing reforms frequently encounter resistance when tariff increases are not accompanied by visible service improvements or social safeguards. Consequently, many countries adopt gradual and differentiated approaches rather than abrupt cost-reflective pricing.

Empirical studies in water-scarce regions reveal mixed evidence regarding the elasticity of irrigation water demand. Farm-level analyses in Algeria suggest that responses to volumetric pricing and quotas depend on crop structure, income

levels, and access to alternative water sources (Oulmane et al., 2019). International experiences demonstrate that pricing reforms are more effective when integrated with non-price instruments such as quotas, groundwater monitoring, modernization subsidies, and farmer awareness programs (Ait Kadi, 2002; Zamani et al., 2021)

The literature also emphasizes the importance of cost recovery for maintaining irrigation infrastructure. Inadequate tariff revenue can undermine operation and maintenance (O&M), reduce service reliability, and ultimately decrease willingness to pay. World Bank (2007, 2018) reports on the Middle East and North Africa highlight that low irrigation tariffs often result in chronic underfunding of irrigation agencies, creating long-term sustainability risks.

In this context, Algeria represents an important case study. The country combines structural water scarcity, a significant agricultural sector, and a historically subsidy-oriented pricing framework. At the national level, Benmihoub and Bedrani (2011) provide evidence on farmer attitudes toward tariff increases in Algerian public irrigation perimeters, while Oulmane et al. (2019) analyze demand responses to volumetric pricing and quota instruments in the Jijel–Taher perimeter. Azzi (2019) offers a detailed analysis of water economics and cost recovery in the Mitidja-Ouest public perimeter. These Algerian studies collectively document the gap between nominal tariff levels and actual cost recovery, yet comprehensive evaluations linking tariff design, scarcity signals, and long-term sustainability remain limited. By situating Algeria within the broader Maghreb and international debate on irrigation water pricing under scarcity, this study contributes to the literature on economic instruments for sustainable water governance

III. Research Design and Methodology

This study adopts a descriptive–analytical and comparative policy framework. The analysis integrates three levels of evaluation: (i) structural scarcity assessment, (ii) tariff design and cost-recovery analysis, and (iii) comparative policy benchmarking.

First, structural water stress is assessed using recent internationally harmonized statistics from FAO AQUASTAT (2025). Indicators include total renewable water resources (TRWR), sectorial withdrawals, desalinated water production, irrigated area, and SDG 6.4.2 water stress levels. These indicators provide the macro-level scarcity context within which irrigation pricing operates.

Second, the legal and institutional framework governing agricultural water pricing in Algeria is analyzed, particularly Executive Decree No. 05-14, which defines tariff modalities, volumetric charges, and subscription structures. The evaluation focuses on three economic criteria:

Scarcity signaling capacity – whether tariffs reflect resource scarcity and provide incentives for conservation;

Cost-recovery performance – whether tariff revenue supports operation and maintenance (O&M);

Differentiation and allocative efficiency – whether pricing varies by water source, scarcity level, or crop value.

Third, the Algerian system is benchmarked against selected regional and international experiences. Comparative cases are not used normatively but analytically, to identify design principles applicable under similar scarcity conditions

IV. Results

IV.1 Structural Water Scarcity in Algeria

To contextualize the economic relevance of irrigation pricing reform, it is necessary to assess the structural balance between renewable water resources and total withdrawals. Key macro-level water indicators for Algeria are summarized in Table 1.

Table (1): Renewable Water Resources and Withdrawals in Algeria (2022)

Indicator	Value	Unit
Total Renewable Water Resources (TRWR)	11.67	km ³ /year
Total Water Withdrawals	10.96	km ³
Agricultural Withdrawals	7.39	km ³
Municipal Withdrawals	3.39	km ³
Industrial Withdrawals	0.18	km ³
Water Stress (SDG 6.4.2)	144.81	%
Total Area Equipped for Irrigation	1,365	thousand ha
Area Actually Irrigated	1,065	thousand ha

Source: (FAO, 2025).

The data confirm a structurally tight water balance. Total withdrawals approach renewable resource levels, and agriculture accounts for approximately two-thirds of total use. The reported water stress level above 100 percent indicates severe pressure on renewable freshwater resources. Groundwater

abstraction plays an increasingly important role in meeting demand, raising sustainability concerns.

Population growth further intensifies this imbalance. Holding renewable resources constant, increasing population mechanically reduces per capita water availability. Table 2 illustrates this dynamic.

Table (2): Population Growth and Implied Renewable Water Availability per Capita

Year	Population (million)	Implied TRWR per capita (m ³ /year)
2022	45.5	256
2024	47.0	248
2035	54.2	215
2050	63.9	182

Sources: (FAO, 2025; PRB, 2024).

The decline in per capita availability reinforces the urgency of improving irrigation efficiency and demand management. Under such scarcity conditions, pricing mechanisms are expected to play a central economic role.

IV.2 Irrigation Tariff Structure in Algeria

The effectiveness of irrigation pricing as an economic instrument depends fundamentally on tariff design. Beyond nominal levels, key features include volumetric components, subscription structures, differentiation mechanisms, and cost alignment. The structural characteristics of Algeria's irrigation tariff framework are presented in Table 3.

Table (3): Pricing of Water Supply for Agriculture in Irrigated Perimeters

Perimeter	Volumetric Price (USD/ m3)	Fixed price (USD/l/s/h)
Sig	0.0177	1.775
Habra	0.0177	1.775
Mina	0.0142	1.775
Low Chelif	0.0142	1.775
Middle Chelif	0.0142	1.775
Uper Chelif	0.0177	2.84

Mitidja Ouest	0.0177	2.84
Hamiz	0.0177	2.84
Guelma-Boucheougouf	0.0177	2.84
Safsaf	0.0142	2.84
Bounamoussa	0.0177	2.84
other perimeter	0.0142	1.775

Note: All values have been converted into USD/m³ for comparability purposes based on official tariff data from Executive Decree No. 05-14. **Source:** Executive Decree No. 05-14, issued on January 9, 2005.

Table 3 indicates that Algeria's irrigation pricing system combines subscription elements with relatively low volumetric charges. While such a structure may reduce administrative complexity, it also limits the capacity of prices to function as effective scarcity signals.

The limited differentiation across regions, water sources, or crop types suggests that tariff design prioritizes uniformity over allocative precision. From an economic standpoint, scarcity pricing requires some degree of differentiation reflecting cost structures, water source characteristics, or usage intensity (Rogers et al., 2002). In the absence of such differentiation, tariffs may remain largely symbolic and weakly responsive to regional water stress variations.

Therefore, the current tariff structure raises questions regarding its ability to influence cropping decisions or encourage investment in water-saving technologies.

IV.3 Cost Recovery and Financial Sustainability

Beyond scarcity signaling, irrigation pricing plays a critical institutional role through cost recovery. Financial sustainability of irrigation infrastructure depends on sufficient revenue to cover operation and maintenance (O&M) expenditures. Available evidence on tariff performance is summarized in Table 4.

Table (4): Coverage Rate of Volumetric Pricing for Irrigation Costs in Different Agricultural Irrigation Perimeters in Algeria.

Perimeter	Volumetric Price (USD/ m3)	Average Cost (USD/ m3)	Average Coverage rate (Price/Cost)
Sig	0.0177	0.0180	0.98
Habra	0.0177	0.0520	0.34

Mina	0.0142	0.0351	0.41
Low Chelif	0.0142	0.0217	0.65
Middle Chelif	0.0142	0.0376	0.38
Uper Chelif	0.0177	0.0522	0.34
Mitidja Ouest	0.0177	0.1532	0.12
Hamiz	0.0177	0.0970	0.18
Guelma-Boucheougouf	0.0177	0.1063	0.17
Safsaf	0.0142	0.0470	0.30
Bouamoussa	0.0177	0.0714	0.25
Other perimeter	0.0142	0.0922	0.15

Source: by the author from the National Bureau of Irrigation and Drainage, as published in the appendices of the study (Azzi, 2019).

The data suggest that cost recovery remains partial in several irrigation perimeters. When tariff revenue falls short of O&M requirements, irrigation agencies rely on public transfers to maintain infrastructure.

Partial cost recovery generates structural risks. First, underfunded maintenance may deteriorate service reliability. Second, declining service quality can reduce farmers' willingness to pay, reinforcing a low-revenue equilibrium. Third, inadequate pricing may indirectly encourage groundwater overexploitation, as users seek alternative supply sources.

World Bank (2007, 2018) emphasizes that sustainable irrigation systems require alignment between tariff revenue and service provision costs. The gap identified in Table 4 therefore constitutes not merely a fiscal issue, but an institutional sustainability concern.

IV.4 Comparative Policy Analysis

Comparative experience provides insight into alternative irrigation pricing designs under scarcity conditions. The purpose of comparison is analytical rather than prescriptive: to identify structural features that enhance scarcity management and financial sustainability.

Table (5): Regional Irrigation Pricing Models

Country	Volumetric Price (USD/m ³)	Cost Recovery Rate	Key Policy Features	Challenges/Impacts
Algeria	0.0142 - 0.0177	Partial (subsidized), ~36% in Average.	Mixed tariff (fixed + volumetric); highly subsidized; no differentiation by source, scarcity, or crop value.	Weak price signal, over-irrigation (~30–40% water loss), aquifer depletion, and financial unsustainability of irrigation services.
Tunisia	Lower than Morocco 0.022 – 0.076	Partial (subsidized)	Progressive pricing for domestic use; advanced drought management; incentives for treated wastewater use; focus on equity and sustainability.	Limited incentive for efficiency; weak cost transparency; farmer resistance to tariff reforms.
Morocco	0.070 – 0.078	Partial (subsidized)	Differential regional pricing; user-pays principle; farmers contribute to investment and O&M costs; integrated water resources management.	High treatment costs; inefficiency persists; political resistance to pricing reforms.

Source: By the author based on: (Ahmad, 2000; Al-Saidi, 2017; Baroudy, 2005; Ben Zaied et al., 2017; Chemingui & Thabet, 2016); related regional literature.

Regional cases illustrate three recurring design principles. First, differentiated tariff structures—often incorporating progressive or block pricing—allow protection of smallholders while charging higher marginal rates to larger users. Second, tariff adjustments are typically gradual rather than abrupt. Third, pricing reforms are frequently embedded within broader institutional reforms.

Compared to these models, Algeria’s system appears less differentiated and more administratively uniform. While policy transfer must account for contextual differences, the comparison highlights the structural gap between uniform pricing and scarcity-responsive pricing mechanisms.

International experiences further illuminate the conditions under which irrigation pricing reforms contribute to sustainability. Selected examples are presented in Table 6.

Table (6): International Irrigation Pricing Reforms

Country	Key Policy Features	Noted Impacts/Outcomes
China	Integrated Agricultural Water Pricing Reform (IAWPR) with "reasonable pricing" and "precise subsidies and water-saving incentives," often using differentiated tariffs (e.g., based on irrigation technique, crop type) and quota control.	Significant positive impact on farmers' income (e.g., 31.9% increase in one study) and agricultural productivity; changes in cropping structure, increased water price elasticity, decreased pesticide/fertilizer input; improved water use efficiency and conservation, but with uneven regional progress and financial sustainability challenges.
Spain (Guadalquivir Basin)	Hydro-economic models for regional water pricing, considering regional characteristics.	Water pricing effective in reducing demand if regional characteristics are considered; water availability and crop patterns influence water use reduction; however, water pricing can be a poor policy option in terms of private, environmental benefits, and equity compared to water markets and institutional cooperation.
European Countries	Additional taxes on volumetric water price, differentiation based on scarcity and quality (e.g., X2 for scarcity in France, X3 for drinking water quality in Italy).	Internalizes environmental and resource costs; signals scarcity and promotes conservation; leads to higher water prices, but can face public resistance if affordability concerns are not addressed.
United States	Restrictions on groundwater pumping and adjustments to sectoral water pricing.	Can drastically alter agricultural production, leading to significant losses in some regions (e.g., 25% in Southwest US) balanced by gains elsewhere; requires additional investments for farmers to maintain production with less water.

Source: By the author based on: (Martínez-Dalmau et al., 2023; Mu et al., 2024; Zamani et al., 2021; Zhang & Oki, 2023) ; related empirical studies

International evidence confirms that pricing reforms alone rarely achieve sustainability objectives. Effective systems integrate volumetric pricing with monitoring, quota enforcement, modernization incentives, and institutional accountability mechanisms.

The Algerian case differs primarily in the limited integration between tariff design and scarcity-based differentiation. Without complementary governance mechanisms, tariff adjustments may not generate the intended conservation outcomes.

Thus, comparative analysis reinforces the study's central hypothesis: pricing effectiveness depends not solely on nominal tariff levels, but on structural design and institutional embedding.

V. Discussion

The preceding analysis indicates that Algeria's agricultural water pricing policy presents limited effectiveness as an economic instrument for demand management. This section interprets these findings, examining the factors underlying current policy performance and discussing the implications for water and food security, with reference to regional and international comparisons to identify potential areas for reform.

V.1 The Failure of the Price Signal

The primary function of a price in a market for a scarce good is to transmit information about its scarcity. The tariffs in Algeria (Table 4) demonstrate a limited capacity to fulfill this function. By setting a volumetric charge for a cubic meter of irrigation water at less than two US cents, the current tariff structure does not adequately convey resource scarcity to end users or provide a meaningful incentive for conservation. As numerous studies have shown, when the cost of water constitutes a negligible fraction of a farmer's total production costs (1-10%), there is insufficient economic incentive to invest in water-saving technologies or to manage water use efficiently (Benmihoub & Bedrani, 2011). The demand for irrigation water, which is already known to be relatively inelastic, becomes almost completely insensitive to price changes at these low levels (Berbel et al., 2019; Hanemann, 2005).

Drawing parallels with other countries, the Algerian approach contrasts sharply with those aiming to send clear price signals. For instance, in Iran, water pricing policies are designed to change cropping patterns and irrigation systems, actively motivating farmers towards more efficient practices by signaling the economic value of water (Asaadi et al., 2019; Zamani et al., 2021). Similarly, European countries like France, Portugal, and Italy incorporate additional taxes on water use, differentiating prices based on scarcity and quality, thereby internalizing environmental and resource costs (Berbel et al., 2019). Algeria's

"one-size-fits-all" structure further dulls any potential signal, failing to differentiate tariffs to reflect regional scarcity, the environmental cost of depleting groundwater versus using surface water, or the economic value of the crops being produced. This lack of differentiation is a missed opportunity to guide water towards its most efficient and valuable uses, a point that studies from China and Spain highlight by demonstrating the effectiveness of differentiated pricing based on regional characteristics, irrigation methods, and crop types (Martínez-Dalmau et al., 2023; Mu et al., 2024).

V.2 The Vicious Cycle of Financial Unsustainability

The significant gap in cost recovery, as shown in Table 4, represents not only an immediate fiscal shortfall but also a structural weakness that contributes to a feedback loop often referred to as the “vicious cycle of underfunding” (Kass et al., 2023). This cycle, clearly evident in Algeria, unfolds as follows: artificially low tariffs generate insufficient revenues for water agencies, which in turn are unable to finance adequate operation and maintenance. Consequently, irrigation infrastructure—canals, pipes, and pumps—deteriorates, leading to high water losses and unreliable service for farmers. Faced with declining service quality, farmers’ willingness to pay decreases, creating political pressure to maintain low tariffs and perpetuating the cycle. Over time, this dynamic institutionalizes inefficiency and accelerates the degradation of billions of dollars’ worth of public irrigation assets.

This challenge of financial unsustainability is not unique to Algeria, but its severity is exacerbated by the country's reliance on heavily subsidized water. In contrast, countries undertaking successful reforms, such as China, have focused on integrated agricultural water pricing reforms that incorporate "reasonable pricing" alongside "precise subsidies and water-saving incentives" (Zhang & Oki, 2023). These reforms have not only improved water use efficiency but have also demonstrated a positive impact on farmers' income, enabling a more sustainable financial model for water management (Mu et al., 2024). Tunisia's experience also underscores the difficulty of achieving successful reform when cost estimation lacks transparency (Thabet & Chebil, 2006). Algeria's situation, where subsidies are linked to oil production and low cost recovery is the norm (WB, 2007), creates a significant disincentive for financial autonomy and sustainable investment in water infrastructure. Jordan's struggle to make pricing policies effective without positive incentives further highlights that pricing is part of a larger ecosystem of policies (Venot & Molle, 2007).

The Algerian water pricing system, when examined through the lens of economic efficiency and financial sustainability, exhibits several critical flaws. These are summarized in Table 7 and detailed below.

Table (7): Key Deficiencies in Algeria's Agricultural Water Pricing Policy

Deficiency	Description	Consequence
Failure to Reflect Scarcity	Tariffs are uniform and do not vary based on regional water stress levels. Water is priced the same in a water-rich area as in a drought-prone one.	Fails to send a price signal about resource scarcity, encouraging inefficient use in the most vulnerable regions.
Failure to Differentiate Water Source	The policy does not distinguish between renewable surface water and finite, non-renewable groundwater.	Leads to the unsustainable "mining" of strategic groundwater aquifers, as there is no economic disincentive for their over-extraction.
Neglect of Crop Value	The tariff is the same regardless of the crop being grown. Low-value fodder crops are charged the same as high-value vegetables.	Results in an inefficient allocation of scarce water to low-productivity uses, reducing the overall economic output of the agricultural sector.
Chronic Failure of Cost Recovery	Revenues from water tariffs are insufficient to cover the full operation and maintenance (O&M) costs of the irrigation infrastructure.	Leads to the "vicious cycle" of underfunding, infrastructure decay, poor service, high water losses, and user dissatisfaction.
Blunted Incentive for Conservation	Due to heavy subsidies, the cost of water is a minuscule fraction (1-10%) of farmers' total production costs.	Price signals are too weak to influence farmer behavior. There is no meaningful financial incentive to invest in water-saving technology or practices.

Source: Derived by the author from the preceding analyses and regional/international comparisons.

V.3 A Vision for a Reformed Pricing Policy

Breaking this cycle requires a courageous and comprehensive reform. It is not about punishing farmers but about creating a rational system that ensures long-term sustainability. The principles for such a reform are well-established in water economics literature:

- Financial Sustainability as a Goal: A clear, long-term, and transparent plan to gradually raise tariffs to a level that ensures full recovery of O&M costs is the essential first step. This can be supported by diversifying funding channels,

as highlighted by China's reform (Zhang & Oki, 2023).

- **Differentiated and Smart Tariffs:** The new structure must be nuanced. It should incorporate higher prices in water-scarce regions, a premium on groundwater to reflect its depletion cost, and perhaps discounts for efficient irrigation methods to create a positive incentive. This approach is evident in China, where pricing varies based on irrigation techniques and crop types, and in European countries that impose additional taxes for scarcity and quality (Berbel et al., 2019; Zhang & Oki, 2023). Spain's experience also emphasizes tailoring pricing to regional characteristics for effectiveness (Martínez-Dalmau et al., 2023).

- **Social Equity through Block Tariffs:** To protect vulnerable smallholders, a rising block tariff structure is the ideal model. This provides a basic amount of water at a low price, with progressively higher rates for larger volumes of consumption, ensuring that affordability is maintained for subsistence needs while large commercial users face the true cost of the resource. This is crucial for managing the socio-economic impacts of pricing reforms (YING et al., 2015).

- **Integration with a Policy Package:** Pricing reform cannot succeed in a vacuum. It must be supported by non-price instruments, such as the establishment and enforcement of water abstraction quotas (as seen in the US and China for groundwater), technical support for farmers, and robust public awareness campaigns to build consensus and explain the necessity of the reform (Graham et al., 2021; Zhang & Oki, 2023). China's precise subsidies and water-saving incentives offer a model for addressing farmer welfare during transitions (Zhang & Oki, 2023). Furthermore, improving the quality of irrigation facility maintenance and strengthening the interface between property rights reform and water management policies can enhance farmers' water conservation behavior (Feng et al., 2023).

These measures align with global best practices in integrated water resources management (IWRM) and reflect the United Nations' call for sustainable water governance as articulated in SDG 6 (UN-Water, 2021).

VI. Conclusion

This study contributes to the growing body of literature on sustainable water management by offering a critical evaluation of Algeria's agricultural water pricing policy through the lenses of economic efficiency, equity, and food security. It highlights how the current tariff structure is fundamentally misaligned with the nation's reality of absolute water scarcity. The results demonstrate that the existing system—with its extremely low tariffs—fails on every major

economic criterion: it does not signal scarcity, it does not incentivize efficiency, and, most critically, its failure to recover costs has trapped the water sector in a vicious cycle of underfunding and infrastructure degradation. Although politically expedient, the current policy is both economically and environmentally unsustainable.

The evidence, reinforced by regional and international comparisons, indicates that a comprehensive and graduated reform of agricultural water pricing constitutes a significant policy priority. Maintaining the current framework carries economic and environmental risks, as it may perpetuate inefficient resource use and undermine long-term food security. The path forward requires a carefully designed transition toward a pricing system that more accurately reflects resource scarcity, supports the financial sustainability of water services, and provides farmers with appropriate incentives to enhance efficiency. Such reform, integrated within a broader policy framework that includes targeted subsidies, differentiated tariffs, and robust regulatory mechanisms, is essential for building a resilient, water-secure, and food-secure future for Algeria.

Nonetheless, this research faces certain limitations. The analysis relies primarily on secondary data and official statistics, which may not fully capture the heterogeneity of irrigation practices or regional variations in water use efficiency. Future research should incorporate field-based data, behavioral analyses of farmers' responses to pricing reforms, and comparative studies across regions to better understand the socioeconomic and environmental implications of various pricing strategies.

Looking ahead, the study opens several avenues for future inquiry. First, field-based research incorporating farm-level surveys and behavioral analyses would provide granular insight into farmer responses to pricing changes across different agro-ecological zones and irrigation perimeters in Algeria. Second, econometric modeling of price elasticity of irrigation water demand, disaggregated by crop type, water source, and region, would enable more precise estimation of the demand-management potential of tariff reform. Third, comparative studies within the Maghreb—particularly examining the Algerian, Tunisian, and Moroccan experiences in parallel—could yield policy-relevant lessons adapted to shared regional conditions of water scarcity and agricultural structure. Fourth, assessment of incentive-based instruments such as tradable water rights, irrigation modernization subsidies, and performance-based contracts could complement pricing reform and provide complementary pathways to efficiency. Fifth, integrated water–food–climate governance frameworks, encompassing cross-sectoral coordination, digital water monitoring, and innovative public financing mechanisms, deserve dedicated investigation. Ultimately, this study lays the groundwork for evidence-based reforms that

harmonize economic rationality with social equity and environmental sustainability.

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