

A DISRUPTIVE APPROACH TO THE REUSE OF TREATED WASTEWATER IN SOUTHERN TUNISIA

UNE APPROCHE NOVATRICE DE LA REUTILISATION DES EAUX USEES TRAITEES DANS LE SUD DE LA TUNISIE

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ABSTRACT

This article presents the results of a feasibility study conducted by the Mediterranean Water Institute, with financial support from the Rhône Mediterranean Corsica Water Agency, across three governorates in Southern Tunisia (Sfax, Gabès and Médenine) during 2025–2026. Facing chronic water scarcity, with renewable water resources below 450 m³ per capita per year, Tunisia is accelerating the development of non-conventional water resources to secure agricultural, industrial and urban water supplies. The study proposes an innovative and integrated model based on a single operator covering the entire multi-use treated wastewater (TWW) reuse value chain, supported by a blended finance approach.

An original 35-year economic model demonstrates that the long-term economic viability of treated wastewater reuse depends on three key conditions: user diversification, sufficient geographical coverage to achieve economies of scale in infrastructure and operating costs, and long-term stakeholder commitment. High-value uses such as industry, tourism, and environmental and nature-based solutions emerge as essential complements to agricultural reuse, ensuring both operator financial viability and affordable irrigation tariffs. The findings support a paradigm shift from wastewater disposal toward a circular water economy in which treated wastewater becomes a strategic asset for water security, climate resilience and sustainable development in Southern Tunisia.

Keywords: Multi-use treated wastewater reuse; Economic model; Operating costs; Long-term stakeholder; Water economy.

RÉSUMÉ

Cet article présente les résultats d'une étude de faisabilité menée par l'Institut méditerranéen de l'eau, avec le soutien financier de l'Agence de l'eau Rhône-Méditerranée-Corse, dans trois gouvernorats du sud de la Tunisie (Sfax, Gabès et Médenine) entre 2025 et 2026. Confrontée à une pénurie chronique d'eau, avec des ressources en eau renouvelables inférieures à 450 m³ par habitant et par an, la Tunisie accélère le développement de ressources en eau non conventionnelles afin de garantir l'approvisionnement en eau des secteurs agricole, industriel et urbain. L'étude propose un modèle innovant et intégré reposant sur un opérateur unique couvrant l'ensemble de la chaîne de valeur de la réutilisation polyvalente des eaux usées traitées (EUT), soutenu par une approche de financement mixte.

Un modèle économique original s'étalant sur 35 ans démontre que la viabilité économique à long terme de la réutilisation des eaux usées traitées dépend de trois conditions essentielles : la diversification des utilisateurs, une couverture géographique suffisante pour réaliser des économies d'échelle au niveau des infrastructures et des coûts d'exploitation, ainsi que l'engagement à long terme des parties prenantes. Les utilisations à forte valeur ajoutée, telles que l'industrie, le tourisme et les solutions

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environnementales et fondées sur la nature, apparaissent comme des compléments essentiels à la réutilisation agricole, garantissant à la fois la viabilité financière de l'opérateur et des tarifs d'irrigation abordables.

Ces résultats plaident en faveur d'un changement de paradigme, passant de l'évacuation des eaux usées à une économie circulaire de l'eau dans laquelle les eaux usées traitées deviennent un atout stratégique pour la sécurité hydrique, la résilience climatique et le développement durable dans le sud de la Tunisie.

Mots-clés : Réutilisation polyvalente des eaux usées traitées; Modèle économique; Coûts d'exploitation; Engagement à long terme des parties prenantes; Economie de l'eau.

TUNISIA FACING THE WATER EMERGENCY

Tunisia is one of the Mediterranean countries most exposed to the effects of climate change on water resources. With less than 450 m³ of water available per capita per year, it falls below the absolute scarcity threshold defined by the United Nations (500 m³/capita/year), a level projected to deteriorate further to 387 m³/capita/year by 2050 according to Tunisia's National Water Strategy. This structural water pressure primarily affects the agricultural sector, which accounts for up to 80% of water withdrawals (FAO Aquastat, 2024) and plays a central role in food security — representing up to 40% of employment in southern rural areas. The deterioration of conventional resources directly undermines the resilience of these territories. The national Water and TWW Reuse strategies set a target of 75% TWW reuse by 2050. In 2025, 280 million m³ of TWW are produced through 120 treatment plants, but only 8% are effectively reused. A TWW decree establishing quality classes is currently under validation (2026). The dominant approach to date has been to subsidize TWW reuse through public funding, without achieving a self-sustaining and durable dynamic.

This article explores a structurally different alternative: entrusting the overall management of TWW reuse to a single operator — public, private, or through a Public-Private Partnership (PPP) — capable of covering the entire value chain, from the outlet of the treatment plant to the end user, across a territory large enough to achieve the necessary user diversification and economies of scale for economic viability. It is this single-operator logic, combined with multi-use tariff optimization and blended finance, that lies at the heart of the feasibility study conducted by the *Mediterranean Water Institute (IME)*, with the support of the *Rhône Mediterranean Corsica Water Agency (AERMC)*. The scope — the governorates of Sfax, Gabès and Médenine — anchors the analysis in real data without limiting its broader applicability. A key innovation of the study is the development of an optimization model capable of determining the tariff mix that simultaneously protects agricultural users while ensuring operator financial equilibrium.

METHODOLOGY: A FIELD-BASED AND MULTIDISCIPLINARY APPROACH

The study was conducted from July 2025 to June 2026 using a methodology combining primary field data collection, economic modelling and participatory validation, in line with the orientations of Tunisia's National Water Strategy, National TWW Reuse Strategy, and National Climate Change Adaptation Plan. Field missions were conducted in three successive series, covering the full geographical and institutional scope of the study.

Mission 1 — July 2025 (launch and data collection)

Official launch of the study with meetings at the highest institutional level — Minister of Agriculture and Water Resources, Secretary of State for Water Resources — as well as working sessions with the main national technical bodies (ONAS, SCET, STUDI, SCAT, SECADENORD, SONEDE) and cooperation partners.

Mission 2 — October 2025 (TWW Steering Committee and field visit in Sfax)

Meeting of the national TWW Steering Committee, whose members expressed the wish to extend the study's conclusions to the entire Tunisian territory; meeting with the PPP General Inspectorate; field visits in Sfax (treatment plants and irrigated areas, CRDA and SCAST meetings).

Mission 3 — November 2025 (full coverage of the study area)

Visits to all 13 treatment plants and irrigated areas in the three governorates; meetings with CRDAs and actors from industry, tourism and the environment in Sfax, Gabès and Médenine; closing meeting of the national TWW Steering Committee. These three missions enabled the collection of physical and economic data on the treatment plants, assessment of the condition of irrigated areas, identification of potential industrial and tourism uses, and measurement of the willingness to pay of the various user categories.

Economic modelling

Economic modelling led to the development of an original tool specifically designed for this project (described in section 4), simulating economic viability over 35 years under different usage scenarios and tariff assumptions. It builds on existing studies and integrates data collected in the field.

Multi-stakeholder workshops

Participatory validation took the form of three multi-stakeholder workshops held in each governorate (Sfax, 11 May; Gabès, 12 May; Médenine, 13 May 2026), bringing together 66 participants representing CRDAs, ONAS, SCAST, municipalities, GDAs, industrial and tourism sectors, and research institutions.

THE TWW REUSE SYSTEM IN SOUTHERN TUNISIA:

Potential and Constraints

A Considerable and Under-Exploited Potential

The annual volume of TWW available for reuse in the three governorates of Sfax, Gabès and Médenine reaches 32 million m³ within the 13 treatment plants of the SCAST-ONAS concession, of which 24 million m³ are available for reuse under a 75% reuse target. Against this potential, current reuse rates are modest: 8% in Sfax, less than 5% in Gabès, and only 1 to 2% in Médenine from its 8 million m³ available. The extension potential is documented: 10,000 additional irrigated hectares have been identified across the three governorates (CRDA Sfax/Gabès/Médenine, 2025), alongside industrial, tourism (Djerba hotels and golf courses) and environmental uses (recharge of coastal aquifers threatened by saltwater intrusion).

Structural Constraints to Overcome

Several constraints hamper TWW reuse development in the region. Technically, some existing infrastructure requires rehabilitation or replacement, and current standards (NT 106.03, 1989) need updating to address all health risks — which the draft TWW decree addresses precisely, by introducing a quality class system and barrier measures tailored to each use. Economically, the current financing model — entirely public — is insufficient and creates no incentives for efficient resource use. In terms of governance, fragmentation between ONAS, CRDA, GDAs and local authorities generates operational coordination difficulties that argue for creating a single operator capable of managing the entire service — from TWW mobilisation to delivery to users — and pooling investments across an extended territory. This is precisely the object of the PPP logic developed in this study.

Beyond these technical and institutional constraints, a fundamental social challenge is identified across all three governorates: the distrust of a proportion of users towards TWW. A structured awareness strategy, backed by rigorous quality control, is deemed indispensable by all stakeholders. The case of

El Hancha (Sfax), which has been irrigating 50 ha of olive groves and fodder crops since 2009 without documented contamination, demonstrates that this trust can be built when quality is guaranteed and monitored (field mission report, September 2025).

THE ECONOMIC MODEL: A DECISION-SUPPORT TOOL

Architecture and Logic of the Model

An original economic model was specifically developed for this study, drawing on existing data and studies while enriching them with field observations. It constitutes a decision-support tool for Tunisian public authorities, structured from the perspective of a single economic operator subject to a financial equilibrium constraint. Its main characteristics are:

- A 35-year simulation horizon, consistent with the envisaged duration of a PPP contract (25-35 years) and investment cycles in hydraulic infrastructure.
- A bottom-up approach: the model integrates the actual physical characteristics of the 13 treatment plants — volumes, distances, uses — as the source of truth. Each plant is individually classified as "Rural Type" (predominantly agricultural use) or "Urban Type" (predominantly industrial, tourism or collective use).
- A modelling scope anchored in a concrete case — the three governorates of Sfax, Gabès and Médenine, whose treatment plants are covered by the SCAST-ONAS concession, used here as a geographical reference boundary — with an annual reusable volume of 24 million m³ and a reference treatment plant/user distance of 5 km — a highly sensitive parameter.
- Five user categories: Farmers/GDAs, Industry, Tourism, Local Authorities, and Aquifer Recharge/Environment (Nature-Based Solutions).
- Activatable ancillary activities: photovoltaic energy production near irrigated areas, greywater treatment, and carbon credits.

The model evaluates the intrinsic economic profitability of the project — its capacity to generate value through its operational activity, independently of the financing structure. This approach is also justified by the fact that the project could be implemented entirely by the Tunisian State, without resorting to external private financing — drawing solely on technical expertise — with financing then provided through public resources or sovereign loans. In this scenario, economic profitability constitutes a sufficient viability indicator, independently of the cost of capital.

The Value Chain and Global Service to Farmers

The approach rests on a single operator covering the entire TWW value chain, from treatment plants to end users: TWW mobilization and tertiary treatment, transport, distribution, drip irrigation within perimeters, nearby photovoltaic production, and greywater treatment for coastal hotels. This model breaks with the traditional approach by entrusting a single actor with responsibility for the entire service, under the supervision of the State's sovereign functions. For the agricultural sector, the operator provides a global service — quality-guaranteed TWW, irrigation infrastructure, competitive-cost PV energy, technical support — not merely a volume of water delivered. The price paid covers this integrated service, justifying a tariff level above the current subsidized model, while remaining advantageous compared to the full cost of an independent borehole.

The Tariff Optimization Module

One of the most significant methodological innovations is the automated price mix optimization module. Its objective is to determine the optimal combination of TWW selling prices for different user categories that achieves the project's economic equilibrium ($\text{Profit} \geq 0$) while minimizing the overall tariff burden. The optimizer systematically explores all possible price combinations within predefined Min/Max ranges. It proposes three solutions: (a) minimization of the weighted average cost; (b) priority protection of farmers; (*) composite compromise. This approach transforms the tariff question from an empirical negotiation into a data-driven optimization exercise.

SCENARIOS AND MODELLING RESULTS

The Four Scenarios Explored

Four scenarios were modelled, corresponding to increasing configurations of user diversification, in line with the orientations of the National TWW Reuse Strategy:

- **Scenario A** (100% agricultural): all treatment plants classified under rural use — baseline case representative of the current situation.
- **Scenario A-bis** (~67% agricultural, ~33% industrial): first introduction of multi-use.
- **Scenario B** (~25% rural, ~75% urban): predominantly industrial, tourism and collective use.
- **Scenario C** (~49% rural, ~51% urban): balance between rural and urban uses, with 20% dedicated to environmental uses — the most comprehensive scenario, with all 5 user categories active.

Tariff Optimisation Results

Tariff optimisation reveals contrasting dynamics depending on the scenarios and objectives pursued. The results are organized around three main readings. In Scenario A (100% agricultural), all configurations tested lead to the same finding: economic equilibrium ($\text{Profit} \geq 0$) is not achievable, regardless of configuration (5 km or 10 km, with or without ONAS fee). Agricultural water pricing is constrained to very low levels (cap of 0.50 TND/m³), insufficient to cover the CAPEX and OPEX of a dedicated network. The absence of user diversification deprives the optimizer of any cross-subsidy lever: this scenario is not viable without significant public subsidy.

- **Scenario A-bis** (Farmers + Industry) marks a turning point: the introduction of a minority industrial use is sufficient to restore financial equilibrium. The Compromise solution (*) gives: farmers at 0.05 TND/m³, industry at 1.21 TND/m³: equilibrium is achieved but without a safety margin.
- **Scenario B** (Farmers, Industry, Tourism, Local Authorities): Compromise solution (*): farmers 0.05; local authorities 0.40; tourism 1.00; industry 1.80 TND/m³; weighted average price 0.90 TND/m³.
- **Scenario C** (five categories, including environmental uses Aquifer/NBS) is the most comprehensive and constitutes the reference configuration. Activating the fifth category achieves financial equilibrium, but generates lower profitability than Scenario B. The tariff structure remains highly differentiated: farmers at 0.05 TND/m³, local authorities at 0.80, aquifer recharge at 1.00, industry at 1.40, tourism at 1.60 — with a standard deviation of 0.54, reflecting significant cross-subsidization between categories.

Key Findings

- First finding: User diversification is the structural condition for viability: each additional category with strong contributive capacity improves system equilibrium through cross-subsidization.
- Second finding: Scenario B is the reference configuration for PPP negotiation: 35-year profit, protected agricultural price at 0.05 TND/m³, weighted average price 0.90 TND/m³. Scenario C achieves equilibrium with five categories but generates lower profit.
- Third finding: Scenario A is structurally unviable without public subsidy: Profit ≥ 0 is not achievable across all configurations tested.

Sensitivity Analysis: Treatment Plant/User Distance and TWW Purchase Cost from ONAS

Beyond the four usage mix scenarios analyzed in the previous sections, the model was subjected to a systematic sensitivity analysis covering two parameters of different nature but closely linked to the viability of the single operator. The first is the distance between treatment plants and end users (5 km versus 10 km), which directly determines the sizing and cost of transport infrastructure.

The second is the TWW purchase cost from ONAS (0 TND/m³ or 0.225 TND/m³), which constitutes a direct operating cost for the operator. These two parameters were combined across 17 simulations covering all scenarios, with and without photovoltaic production.

Distance: the most discriminating factor.

Among all 17 configurations tested, the only four profitable configurations (excluding financing) are all at 5 km distance. At 10 km, no configuration achieves equilibrium without constraining industrial prices to their maximum level (3 TND/m³), which undermines commercial viability and renders these configurations unacceptable in practice. This result reflects the extreme sensitivity of network CAPEX to pipeline length: double the distance does not mean double the cost, but a cost structurally incompatible with admissible tariff levels for agricultural and collective users. This constitutes a direct operational technical criterion for selecting priority treatment plants and delineating concession areas.

ONAS cost: a significant but absorbable charge in Scenario B.

The introduction of a 0.225 TND/m³ fee paid to ONAS does not mechanically eliminate profitability in Scenario B at 5 km. However, it requires a significant increase in industrial prices (from 1.80 to 2.30 TND/m³) and tourism prices (2.00 TND/m³), generating a profit of 1,248,801 TND over 35 years — approximately 36,000 TND/year. Free TWW remains a significant structural advantage, particularly in Scenarios A-bis and C where margins are narrow.

THE PPP STRUCTURE AND BLENDED FINANCE

The Institutional PPP, Single Operator and Territorial Dimension

Institutionally, the single-operator logic — whether involving a public operator, a private operator, or a Mixed Economy Company (SEM) within a PPP framework — is inseparable from a reflection on the relevant territory of intervention. The economic viability of a TWW reuse project rests on three closely linked conditions: (i) a sufficiently diversified client base to enable cross-subsidisation between user categories; (ii) sufficient TWW volumes to achieve economies of scale on infrastructure and OPEX; (iii) a controlled treatment plant/user distance to limit transport costs. These three conditions argue for a large intervention territory, entrusted to a single operator with the vision and technical capacity to optimise the global value chain. An operator intervening plant by plant, without an integrated territorial vision, will be unable to achieve the necessary economies of scale or offer an attractive global service to different user categories. The draft TWW decree, currently under validation, constitutes a strategic

window of opportunity: it must be completed to transform a purely technical framework into an operational legal framework enabling effective PPP structuring — notably through recognition of TWW as a reusable economic resource and explicit provision for PPP recourse.

The Integrated Value Chain

The operator's value chain covers: TWW mobilisation, modern irrigation within perimeters, PV production and hotel greywater treatment. This revenue diversification improves overall profitability and enhances the project's attractiveness to a private operator.

Blended Finance: A Sine Qua Non Condition

The profitability levels of realistic scenarios do not allow for conventional private financing. The architecture rests on blended finance with five components:

- **Level 1** — Climate grants and donations: via multilateral funds and DFIs: non-reimbursable contributions, the primary risk reduction lever.
- **Level 2** — Long-term concessional debt: MDB and bilateral agency loans at 20-25 years, conditional on the sovereign guarantee of the Tunisian State.
- **Level 3** — Medium-term commercial debt for the most profitable components (industrial and tourism uses).
- **Level 4** — SEM equity: contribution from the single operator and in-kind contribution from ONAS (TWW access right).
- **Level 5** — Innovative mechanisms: carbon credits, green bonds, payments for environmental services (aquifer recharge).
- The adoption of the TWW decree and the establishment of the Tunisian State's sovereign guarantee constitute the two non-negotiable prerequisites for mobilizing this blended finance within timeframes compatible with the project's ambitions.

LESSONS FROM PARTICIPATORY WORKSHOPS

The three workshops conducted in May 2026 brought together 66 participants representing the full range of territorial stakeholders. Their lessons complement and nuance the modelling results.

Trust as a prerequisite.

All three governorates converge: the barriers to TWW reuse adoption are primarily social and perceptual. The memory of past difficulties, usage constraints perceived as disproportionate, and regulatory ambiguity create a distrust that only State-led independent quality control and structured communication can overcome.

Tariff differentiation, a unanimously accepted principle.

All participants recognize that each user category must contribute according to its capacity and the benefits it derives. This principle validates the model's multi-use logic. Acceptable price ranges: farmers between 0.050 and 0.300 TND/m³; tourism identified as the category with the highest contributive potential, potentially reaching 3-6 TND/m³ by 2050 according to Médenine participants.

Mandatory use as a horizon.

Médenine participants put forward a recommendation: TWW use should become regulatory mandatory for certain industrial uses — provided the trust and quality framework is first established. The current

uniform subsidy policy is perceived as creating non-virtuous behaviors without generating lasting commitment.

Tension over distance.

The 5-10 km limit retained in the model creates tension with field realities, with some perimeters located 40 km from treatment plants (Sfax workshop report, May 2026). These issues will be explored further in subsequent studies.

CONCLUSIONS AND PERSPECTIVES

This feasibility study demonstrates that an innovative and interdisciplinary approach to TWW reuse in southern Tunisia is economically viable, provided it breaks with the uniform public subsidy paradigm and adopts a PPP logic integrating user diversification, tariff optimization and blended finance.

Four strategic conclusions emerge.

- First, multi-use is not a secondary objective but the structural condition of economic viability: Scenario B, with four active categories (farmers, industry, tourism, local authorities), offers the best financial equilibrium (35-year profit), at 5 km without ONAS fee. Scenario C, despite activating a fifth category (aquifer/NBS), generates lower profit, with the 20% environmental share insufficiently compensating the additional costs.
- Second, activating high-contributive uses (industry, tourism, aquifer recharge) is the structural lever that protects agricultural tariffs while ensuring overall equilibrium.
- Third, the single operator must cover a geographic area generating sufficient TWW volumes to achieve economies of scale on infrastructure and OPEX.
- Finally, user trust is the critical variable conditioning all model results: without commitment from farmers, industry and local authorities, projected volumes will not be achieved.
- *June 2026.*

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