# TUNISIA
# ESTIMATED COSTS
# FOR THE DEGRADATION AND RESTORATION
# OF WATER RESOURCES
# OF THE MEDJERDA BASIN:
# 2010-2025

**EXECUTIVE SUMMARY**

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| 1 | TUNISIA<br>ESTIMATED COSTS<br>FOR THE DEGRADATION AND<br>RESTORATION OF<br>WATER RESOURCES<br>OF THE MEDJERDABASIN:<br>2010-2025 | SHERIF ARIF AND<br>FADI DOUMANI | HOSNY KHORDAGUI,<br>STAVROS DAMIANIDIS<br>AND VANGELIS<br>KONSTANTIANOS |

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**References:**

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# Executive Summary

## Introduction

In 2013, SWIM-SM published a report on the Estimated Costs for the Degradation and Restoration of the Water Resources of the Medjerda Basin. The objective for this is to help the policymakers, nationally and locally, to identify and prioritize practical actions for improving the management of this basin through the funding potential of projects related to the environmental benefits, and to the reduction of externalities.

The costs of the degradation of the Medjerda basin were estimated at TND 192 million in 2010, with a variation of TND 133 to 295 million, an average equivalent of almost 3.3% of GDP of the Basin region, and almost 0.34% of current Tunisian GDP in 2010. The costs attributable to human health are TND 81 million for 2010, or 42.5% of the cost of degradation of the Medjerda, and 63% in the category of water. Broken down by sub-category for water (TND 130 million in 2010), waterborne diseases account for the majority of the costs of the Medjerda Basin (TND 81 million), followed by water quality (TND 27 million), water quantity (TND 21 million, a relatively low amount as 2010 was a wet season), and finally the overall environment (TND 1 million). Broken down by the sub-category for waste (TND 61 million in 2010), collection represents the majority of Medjerda Basin costs (TND 38 million), followed by waste processing (TND 13 million), landfilling (TND 10 million), and finally the overall environment (TND 1 million).

Based on these results, five focus areas have been proposed for the integrated and sustainable management of water resources of Medjerda. The first intervention was "***The gradual shift towards the policy of intensification of natural resources exploitation***, in particular in connection with the mobilisation of water resources. This shift could be made on the basis of criteria that explicitly include **economic performance, and the degradation and scarcity of the Medjerda Basin resources**". During the presentation of this study to the Executive Committee of SWIM-SM on 11-13 November 2013, the committee requested that this recommendation be investigated by integrating the environmental externalities in the management of the water resources around the Medjerda Basin, given that with its problems of management distribution, exploitation, transfer and water quality, the Medjerda exemplifies the real issue, which is found in other basins in Tunisia.

Following the publication of the report on the Cost of the Degradation and Restoration of the Water Resources of the Medjerda Basin, three major events marked Tunisia's sovereignty over water in 2014. The most important outcome on a political level was the inclusion of the "right to water" in the new Tunisian Constitution, circulated on 27 January 2014, which cites "the duty of the State and society to conserve and rationalise the use of water (Article 44)". The second outcome, on a sectoral level, was the presentation and discussion of the water sector review. This study proposes two recommendations relevant to the review, namely conserving water resources by reducing over-exploitation and pollution, as well as mobilizing, appraising and saving these same water resources by providing an economic dimension to the investments. The third event, which is on a strategic level, was the preparation of the Water Vision and Strategy. The purpose of the vision and the strategy is to "ensure for the 2050 planning horizon, high-powered development and water resource management activities based on a structured, integrated and participatory Water Vision and Strategy".

This is the background to which the water sector's environmental assessment of the Medjerda basin plays its part. The choice of the Medjerda Basin was based on the fact that it is the longest river in Tunisia, and is seen as the country's water tower. Additionally, it is the only river in Tunisia for which the cost of degradation of water resources has been estimated in monetary value.

**Objective**

The objective of this study is to project the results of the estimated costs of the degradation and restoration of the Medjerda basin to incorporate environmental considerations into the support system for decision making, development and prioritization of some of the profitable investment plans. This would make for more ample reflection in the context of the Government's Water Vision and Strategy for 2050.

The added value of this study in relation to the study of the Degradation Cost of water resources of the Medjerda Basin is summarized in Table 1.

*Table 1 : The added value of this study*

The guiding principle of this study is to justify interventions based on the requirement to provide some co-benefits in terms of improving on the one hand, the efficiency of the municipal and agricultural services, and on the other hand, the quality of the resource in order to increase the supply of water resources between 2010 and 2025.

This is done in 4 steps :

- Projecting the water balances and degradation costs between 2010 and 2025, in accordance with a reference scenario.
- Projecting the water balances and degradation costs between 2010 and 2025 in accordance with a water stress scenario where the demand increases by 15%, and the supply decreases by 15%, specifically taking into account effects due to climate change.
- Analysing 4 of the 5 priority and efficient interventions that provide co-benefits:

  - Connecting all rural households to water supply, sanitation and sewer networks, in the Medjerda so as to include the rural area in the reusable water cycle.

  - Improving the efficiency of the water services, reducing (technical) water leakages (by 20%).

  - Improve the quality of water resources by treating all domestic, tourist, industrial and agricultural waste.

  - Improve the efficiency of PIP, optimizing irrigation consumption while capitalizing primarily on resilient outputs on the effects of climate change, with the highest added value (the optimum value required is simply calculated, but the variety of outputs is not suggested).

  - Increasing the storage capacity of the dams by reducing the siltation with reasonable interventions to reduce erosion upstream. Although essential, this priority has not been analysed from an economic aspect while the production of empirical studies to determine causality between the upstream interventions, and the reduction of siltation of the dams and the river bed, is pending.

- Comparing the aggregate priority needs against the evolving cost of desalination over time, to demonstrate the very high profitability of the four priorities for water resources (the best services and remediation), in relation to the desalination option.

This study focusses on the impact of resources and the quality of the water, improving water and sanitation services, especially in rural areas, and the cost of environmental degradation, projecting from 2010 (base year) to 2025, on the basis of two scenarios. These are the reference scenario

reflecting the current situation of the basin, and the evolutionary scenario of water stress, taking into account increase in demand and decrease in supply, mainly due to the impact of climate change.

### General overview of the Medjerda Basin

The Medjerda is divided into three distinct parts. The Higher Medjerda is the highest part of the basin, situated at 1,000 m in Algeria. It rapidly descends to 200 m near to the Tunisian town of Guardimao on the Algerian-Tunisian border, and ends at the great dam of Sidi Salem. The mid-Medjerda ends near the town of El Aarroussia. Its tributaries are the Wadi Khaled and Wadi Siliana. The Lower Medjerda is divided between the two governorates of Ariana and Bizerte, and flows downstream of the El Aarroussia dam to the lagoon Ghar El Mleh near Bizerte, crossing land of below 100 m altitude. The classification of irrigated areas in the three sections is shown in Table 1.

*Table 1 : The Classification of irrigated areas in the three sections of the Medjerda Valley*

| Classification of Major Areas | Governorate | Sub-Classes | Cultural Field | Features |
|---|---|---|---|---|
| Higher and Mid- Medjerda Valley | Jendouba-Béja-Siliana (51,000 ha) | Recent PIP on the dam | Arable crops | Hydromorphy / localized drainage<br>Low intensification in summer<br>The need to rehabilitate the infrastructures |
| | Le Kef-Zeghouan (21,000 ha) | Recent PIP on the drilling site | Arable crops/ Market gardening | Low agricultural intensification |
| Lower Medjerda Valley | Bizerte (16,000 ha) | Recent PIP on the dam | Arable crops | Low agricultural intensification |
| | Ariana-Manouba (21,000 ha) | Recent PIP on the surface | Polycultures | Hydromorphy / drainage<br>Low intensification in winter<br>Very aging infrastructure |

### Sources of Pollution

In the report on the cost of the degradation of water resources of the Medjerda, 2013, the pollution sources were identified as follows:

- Discharge from industrial waste water not connected to the ONAS network
- discharge from treated waste water from STEPs ;
- discharge of untreated urban waste water;
- drainage of untreated rural waste water;
- drainage of pesticides, phosphates and nitrates used for agricultural activities;
- drainages of waste water due to stock raising activities;
- drainage from slaughterhouses;
- The transfer of heavy metals from old mines and one mine still in operation; and
- drainage from solid waste and leachate, especially during the rainy season.

With regard to water usage, mobilized resources are divided into 80% for agriculture, 14% for domestic usage, 5% for industry, and 1% for tourism. However, these apportionments are subject to variations due to the particular year being either very dry, dry or wet. Agriculture receives the lion's

share to ensure 100,000 ha of irrigated perimeters in the basin, and is followed by domestic use, estimated at 179 million $m^3$ for drinking water, much of which is transferred to a part of the East Coast, from Grand Tunis up to Sfax. The Ben Métir and Kessab dams are primarily dedicated to ensuring drinking water due to their low salt content (<1.5 g/L). Transfers to the East coast of Tunisia will continue to increase due to population growth and increased per capita demand, especially for drinking water. The industry consumed 5% of resources in 2010, but this consumption is also likely to increase due to new mining and industrial projects in the perimeter of the basin. However, tourism, especially in Beja and the Grand Tunis, consumed only 1% of this resource.

Quality control of water has shown that Medjerda is highly mineralized. Starting from the Higher Medjerda, salinity begins to increase, with a median of 1 g/L towards the Mid-Medjerda, and 1.3 g/L as it reaches the Lower Medjerda, with a median of 2 g/L, exceeding the European threshold of 0.2 g/L. Groundwater levels are also saline. Levels start from 1.5-2 g/L and can reach 5 g/L due to seawater intrusion, especially in the coastal areas of the Lower Medjerda. The maintenance of the river bed has been neglected on account of sedimentation and vegetation, which in fact have harmful consequences and reduce the flow of the waters. In the Higher and Mid-Medjerda the water flow rate is assumed to be 500 $m^3$/S, reducing to 11 $m^3$/S, with a minimum amount of rainfall causing the riverbanks to overflow. The vegetation in the river bed results from the excessive use of pesticides, phosphate and nitrogen fertilizers, and various pollutants from industrial waste that have helped the spread of this vegetation. The dams, which are interconnected by canals or rivers, are also affected by the vegetation that slows down the flow of the surface waters.

Thus both treated and non-treated domestic, industrial and stock raising waste are estimated to be 20.7 million $m^3$, and the listed agricultural drainages alone reach 0.8 million $m^3$, while there has been a recent attempt at recharging 0.01 million $m^3$ of ground water at Fahs. With regard to the quality of treated domestic waste, at 18.3 million $m^3$, there is room for improvement in some of the STEPs, which have ultimately not helped to improve the basin's water quality and ecosystem.

**The effects of climate change**

In 2007 Tunisia prepared a national strategy for the adaptation of Tunisian agriculture and ecosystems to climate change. This was followed, in 2012, by a national strategy on climate change. The HadCM3 model, projecting the 2020-2050 horizon, showed that in the Medjerda region the average annual increase in temperature is expected to be 0.8°C by 2020, and 1.6-1.8°C by 2050. Average rainfall will decline by 5-8% on the 2020 horizon, and by 11-15% on the 2050 horizon. In addition, the rainfall runoffs may suffer a reduction of up to 10-20% by 2020.

**The Institutional Framework**

With regard to the institutional framework, the management of water resources is still controlled by the state through the three ministerial departments of agriculture, and their corresponding branches of the six Regional Committees for Agricultural Development (CRDA). This policy of decentralization has been accompanied by the establishment of the Associations of Collective Interest (AIC), and Agricultural Development Groups (GDA), that are responsible for managing the distribution of water for drinking and irrigation.

The institutional divisions between, on the one hand the CRDA themselves, and on the other, the environmental authorities (ANPE, ANGed, ONAS, APAL), do not foster a comprehensive approach to the management and protection of natural resources for this basin. Despite the creation of inter-ministerial committees for Medjerda, they are only at a piloting stage for any practical projects, and they have limited impact on the environmental aspects of this basin. Furthermore, the connections

between water and environment, agriculture and environment, and water and climate change are poorly understood. This is because no convincing arguments have been presented, in particular an economic one (cost/benefit analysis, and impact/cost analysis), to convince the stakeholders of the need for integrating environmental aspects into their sectoral strategies. A study on the governance of the Medjerda basin is currently under consideration by the Minister of Agriculture. Four options have been proposed, including: (a) the creation of a river basin agency; (b) a department or a division within the CRDAs; (c) a department in one of the DGRE or DGGREE branches; and (d) a new department in the Ministry of Agriculture.

**Projected Costs of Environmental Degradation**

The study is inevitably subject to several restrictions. From a methodological point of view, the impact of water on the environment has been addressed through a combination of the most suitable economic methods. These have provided results that are reliable in similar contexts and have been tested at basin or surface water levels. Empirically, with the data constraints sometimes imposed, and the use of assumptions and simplifications, conservative assumptions were used in such cases. In other cases, constraints through lack of data have not allowed for the estimates of valuations, which has led to the exclusion of some sub-sectors such as irrigation and certain crops. Therefore, all evaluations should be considered as orders of magnitude rather than as precise estimates. To account for this uncertainty many estimates are presented as ranges of values instead of exact numbers.

It is only the results for the Medjerda basin that are being considered for the provisional costs of the degradation of this area. The costs of the degradation of Greater Tunis is not taken into account. Additionally, 5 major categories were selected, but only 4 were analysed for estimated costs. These were the quality of services causing waterborne diseases, including unimproved access to safe drinking and sanitation; the quality of services associated with the distribution of water in the urban networks; the quality of the water resources as a result of communal waste, covering that of domestic, tourist, industrial and agricultural; and the quantity of water resources and their storage.

**Reference scenario 1: Supply equals demand, and both of these remain constant; present water balance**

Based on the current situation in the Medjerda basin - and without taking into account additional investments for improving the current drinking water supply and sanitation services; the quality assurance departments for drinking water and irrigation, for agricultural runoffs, for management of solid waste; the reduction of risks associated with natural catastrophes (floods etc), in addition to climate change resilience - the cost of environmental degradation was estimated to be TND 102 million, and represents 79% of the cost of degradation of the water resources of the Medjerda basin in 2010.

The selected categories include :

i. The quality of water supply and sanitation services in urban and rural areas, and also irrigation;

ii. Quality of the Resource: wastewater, effluents and runoff water;

iii. Quantity of the Resource : reducing the flow of surface water, and lowering the groundwater levels ;

iv. Storage: silting the dams and hill lakes due to erosion and exacerbation by climate change.

The non-selected categories result from the facts that they are difficult to project over 15 years (i, ii and iii), that they are not included in the selected priorities (iv and v), or that the interventions have already been implemented (vi and vii).

i. The salinity of the water;

ii. The effects of erosion on agricultural productivity;

iii. Biodiversity;

iv. Hydroelectricity;

v. Global environment (carbon emissions);

vi. Solid waste (implemented by the NAWM and the KfW);

vii. Flood prevention (implemented by the Ministry of Agriculture and JICA);

The 2010-2025 projections of the reference scenario, or "business as usual" (BAU), showed that the estimated costs of the degradation of water resources in the Medjerda basin reduce in absolute terms (-1.2% /Year over the period 2010-2025, to reach TND 85 million in 2025, which represents 0.13% of Tunisia's GDP for 2010, and 0.09% of Tunisia's projected GDP over this period, and a net growth rate of 3% /Year, Figure 1).

Estimated costs broken down by category (Figure 1) showed that:

i. The quality of the water supply and sanitation services: the burden of waterborne diseases decreases (-1.5% /Year over the period 2010-2025) due to a better health service (gross birth and mortality rates of children under 5 years decrease over this period);

ii. The quality of distribution services increase (+0.9% /Year) due to the increase in water leakages.

iii. The quality of the resource increases (+0.4% /Year) due to population increase, resulting in a larger number willing to pay;

iv. The quantity of the resource remains constant (± 0% /Year) due to the assumption of the reference scenario, where the projection is linear and constant ;

v. Storage remains constant (± 0% /Year) due to the assumption of the reference scenario, where the projection is linear and constant.

**Current Water Balances**

The exploited resources of the Medjerda basin are estimated to be 1.28 million per $m^3$, with surface resources representing 1 million per $m^3$ (Table 2 and Figure 1). In terms of mobilisation , the capacity is 1.26 million per $m^3$ in 2010, and will decline over the period until the completion of the Mellègue Dam in 2020. The other scheduled dams will not be in operation before 2025. With regard to water usage, the distribution of the mobilized resources is 80% agriculture, 14% domestic use, 5% industry and 1% for tourism. However, these allocations are subject to variations due to the particular year being very dry, dry or wet. Agriculture receives the lion's share to ensure 100,000 ha of irrigated perimeters in the basin, and is followed by domestic use, estimated at 179 million $m^3$ for drinking water, much of which is transferred to a part of the East Coast, from Grand Tunis up to Sfax. The industry consumed 5% of resources in 2010 on tourism, particularly in Béja and Greater Tunis, where the use of this resource was still only at 1%.

Data on reusable assets (waste) remains fragmented for Medjerda (Table 2). Thus domestic, industrial and livestock waste, both treated and non-treated, are estimated to be 20.73 million, and the listed agricultural drainages alone reach 0.8 million $m^3$, while there has been a recent attempt at recharging 0.01 million $m^3$ of ground water at Fahs. With regard to the quality of treated domestic waste, at 18.3 million $m^3$, there is room for improvement for some of the STEPs, which have ultimately not helped to improve the basin's water quality and ecosystem.

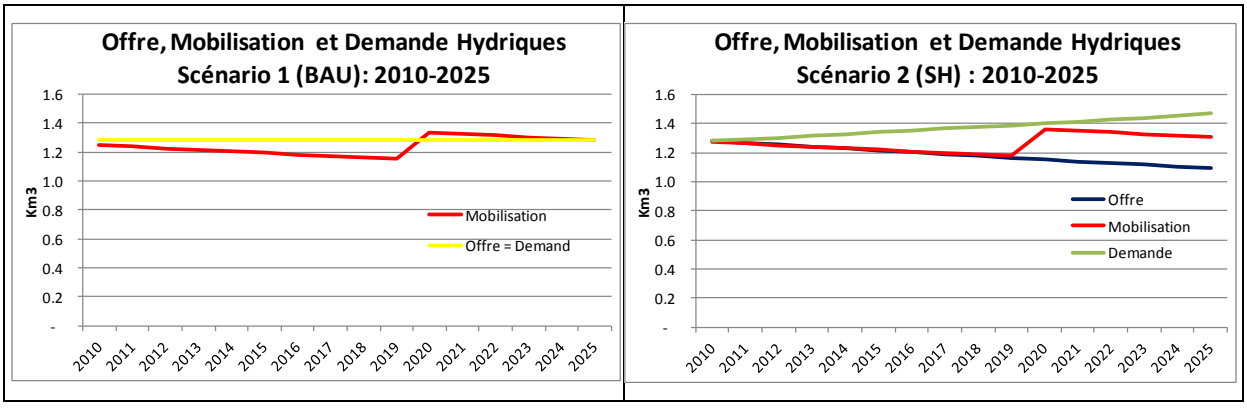
*Table 2 : Supply, Mobilisation and Demand of Water Resources at Medjerda in2010, millions per $m^3$*

| Resources | Potential | Exploited | Mobilised | | Potential reusage in the Medjerda | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cross-border and internal provision | | Dam storage capacity | Storage capacity of hill lakes | Treated domestic/ tourist waste | Non-treated domestic waste | Non-treated industrial waste | Stock-raising waste | Reuse (Fahs) |
| | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ | $Mm^3$ |
| Surface water | >1.000 | 1.000 | 1.100 | 163 | | | | | |
| Ground water | ≈280 | 252 | | | | | | | 0,01 |
| Deep water | ≈230 | 28 | | | | | | | |
| *New dams >2015* | | | *310* | | | | | | |
| **Distrib. of supply=demand:** | | 1.280 | | | | | | | |
| Agricultural | 80% | 1.024 | | | | | | 0,03 | |
| Domestic | 14% | 179 | | | 18,3 | 1,4 | | | |
| Tourist | 1% | 13 | | | | | | | |
| Industrial | 5% | 64 | | | | | 1,0 | | |

**Scenario 2 Water Stress: Gap between supply and demand, future water balance**

The provisional costs of environmental degradation were estimated to be TND 113 million in 2025, which is 0.18% of GDP for 2010, with cumulative costs of TND 280 million over the period, compared to reference scenario 1. According to projections from the ITES (2014), a national water shortage will not occur before 2030. Scenario 2 is based on the assumption that the gap between supply (-15%) and demand (+15%) is widening, and is deemed to reflect the increased demand and the impact of climate change on water resources. This exercise helps to build upon improving the efficiency of the services, the quality of the waste and the optimisation of agricultural productivity, upon reducing the pollution so as to increase the quality of usable stock, and upon comparing the cost of desalination that the Government is considering introducing in order to increase the supply of the resource. Figure 2 illustrates the reference scenario 1 with demand=supply in the first outline, and the scenario 2, water stress, with the demand increasing by 15%, and reducing the supply by 15% over this period. In both scenarios the storage capacity decreases until the impoundment of the Mellègue dam in 2020.

*Figure 1 : Scenarios 1 and 2 for the Supply, Mobilisation and Demand of the Medjerda Basin, 2010-25*




Thus, diversification, integration and, above all, reusing alternative sources of supply are necessary in order to better meet the growing demand. Consequently, the major areas of intervention are:

i. To integrate the rural environment into the water cycle by ensuring there is a connection to drinking water and sewer systems at household level;

ii. To increase the efficiency of drinking water systems;

iii. To process domestic, industrial and agricultural discharge so that they are reused for other purposes or used to recharge the groundwater;

iv. To optimize the consumption and performance of the PIP by selecting outputs that are resilient to climate change, with greater added value; and

v. To develop proven methods of reducing erosion in order to reduce the rate of silting in the dams to preserve storage capacity.

**Provisional costs of the Restoration**

Four of the five selected priorities were analysed with intervention scenarios. These were quality assurance of the rural water and sanitation services; quality assurance of urban and rural distribution; quality of domestic, industrial and agricultural waste contractor resources; and optimising PIP performance by determining added value of the output only without specifying the culture. It is only the upstream erosion causing silting of the dams and hill lakes that was not considered due to a lack of empirical data.

In order to identify the co-benefits of the interventions, these priorities are considered in two stages: individually and in the face of advantages of an improved quality of life, of environmental quality and of efficiency of services; and collectively and in the face of evolving costs of desalination over time (Table 3).

**Restoration on the basis of the priorities considered individually, and in the face of the advantages of health, environmental quality and efficiency of services**: The improvement of water services is by far the most efficient intervention, with an NPV of TND 61 million, an IRR of 112% and a C/B ratio of 6.8, followed by waste treatment (7.35% and 1.3), then by water supply and sanitation (10, 11% and 1.0%), and finally by the optimization of PIP (0.1, 10%).

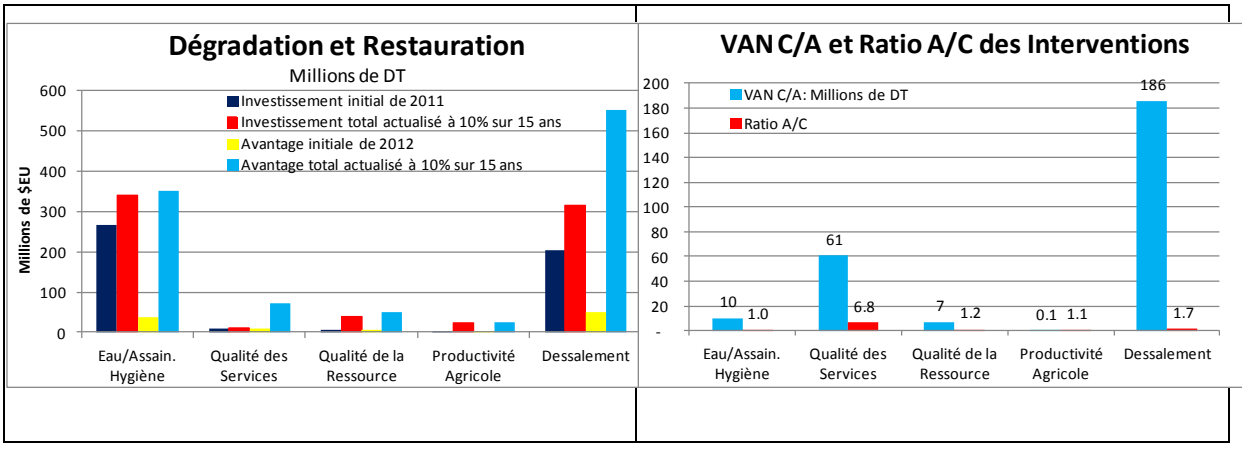
**Restoration on the basis of the priorities considered collectively, and in the face of the evolving costs of desalination over time:** The aggregated costs of the 4 priorities were considered for this cost vs benefits analysis, showing that this intervention is very efficient with an NPV of TND 186 million, an IRR of 23%, and a C/B of 1.7, and even when the discount rates of 5% to 15% are considered to account for the uncertainties associated with climate change.

This latter result has a strategic dimension because it helps to justify the interventions of the 4 priorities: firstly from the perspective of life quality, environmental quality and efficiency of services; and secondly in terms of an alternative to desalination (such as an increased supply of the resource), through conventional interventions of demand management such as service quality, specifically targeting the poor, pollution control and PIP efficiency.

*Table 3 : Provisional costs of the Restoration of Medjerda, 2011-25 and in TND millions*

| Medjerda | 2011 Investment | NPV of Investment | 2012 Benefit | NPV of Restoration | NPV of C/B Analysis | Internal Rate of Return | C/B Ratio |
|---|---|---|---|---|---|---|---|
| | TND million | TND million | TND million | TND million | TND million | ±% | |
| **Priorities 1,2,3 and 4 Considered Individually : Total** | **280** | **415** | **56** | **499** | **78** | | |
| Water Sanitation in Rural Areas | 266 | 341 | 37 | 351 | 10 | 11% | 1,0 |
| Improvement of water supply service | 8 | 11 | 9 | 71 | 61 | 112% | 6,8 |
| Treatment and Waste | 5 | 40 | 7 | 51 | 7 | 35% | 1,3 |
| Optimisation of PIP | 1 | 23 | 3 | 26 | 0,1 | 10% | 1,0 |
| **Priorities 1,2, 3 and 4 Aggregated and compared to the expected 10% cost of desalination** | **203** | **315** | **51** | **550** | **186** | **23%** | **1,7** |
| **Awareness** | | | | | | | |
| **Priorities 2, 3 and 4** discounted at 5% | *203* | *338* | *51* | *628* | *357* | *23%* | *1,9* |
| **Priorities 2, 3 and 4** discounted at 15% | *203* | *295* | *51* | *486* | *85* | *23%* | *1,6* |

*Figure 2: Table 3 : Provisional costs of the Restoration of Medjerda, 2010-25 and in TND millions*



**Conclusions and Recommendations**

The diagnosis and analysis that have been developed in this report provide six general conclusions.

The reality facing the people of Medjerda would be to recognize and meet the challenge regarding the new plans associated with water variability and future water scarcity. The rural sector is an important block in the six governorates as it consumes a large proportion of the resource, and is the greater loser when water availability becomes a problem.

The water-related environmental problems are difficult to measure, but its costs are significant in the Medjerda basin. The cost of water-related degradation was estimated at TND 102 million in 2010 (0.16% of 2010 GDP) and TND 85 million (0.13% of 2010 GDP) in 2025, and where supply and demand are constant in the base scenario. In the changing scenario of water stress, where supply will decrease by 15%, demand will increase by 15%, and the implications of climate change will be addressed, the cost of degradation will be TND 113 million (0.18% of 2010 GDP) in 2025. This is a cumulative increase of TND 280 million relative to the reference scenario. On considering scenario 2 on water stress, future water balance will be affected at the same time. The gap between demand and supply could reach 0.25 million $m^3$ in 2020, and 0.37 million $m^3$ in 2025. The mobilisation of water resources cannot fill the gap. On the contrary, it is expected that the curve of this mobilisation will descend from 2020 due to the impoundment of the Mellègue dam.

Evaluating the costs of restoration showed that investments for improving the water quality, sanitation in rural areas, and hygiene awareness make a particular improvement to quality of life. Similarly, service and quality assurance of the resource also generate co-benefits because they increase, on the one hand, water volume by 118 million $m^3$ in 2025 and, on the other, they achieve an NPV of USD 186 million. This is a yield of 23%, and a benefit-cost ratio of 1.7 in 2025, when the aggregate costs of the investments of the 4 selected priorities are compared with the cost of desalination.

It is essential to recognise that the economic and environmental priorities of the water must be addressed simultaneously, and a much more comprehensive approach to the planning and policy development in this basin is vital. It is also essential to recognize that increased variability of rainfall and/or drought not only creates a vulnerable economy, but also causes damage to the ecosystem that is subject to similar pressures due to failure to maintain the river bed and its flanks, as well as taking anti-erosion measures. The natural response of policymakers is to try to alleviate the situation, such as by constructing dams rather than strengthening the institutions and policies, to help the regional economy and the ecosystem withstand the test of time. Sustainable development therefore requires simultaneous planning for these two concerns.

Environmental issues are not always fully considered in the process of decision-making for two reasons related to governance. These are (i) the environmental costs are numerous and difficult to measure, so the policymakers are not often aware of the extent of the problems; (ii) weak regional and local advocacy of environmentalists.

**Recommendations**

In the light of these findings, three areas of intervention are proposed which point to the recommendations of this study, and which complement the recommendations already proposed in the study on the 2013 cost of water resources degradation at Medjderda.

**Supporting the concept of a basin agency for Medjerda**. Water-related environmental problems that have been estimated in monetary value, in the water stress scenario, have shown that it is vital to do away with the status quo of fragmentation of the responsibilities and interventions in each

governorate. There is an urgent need to establish an integrated management of the basin in which the management of the water must be done at basin level for allocating water, monitoring, compliance, and involving and interacting more closely with the water users and operators.

Since the establishment of a basin agency would require a legal and institutional framework in which policymakers cannot make judgements in the short term, a permanent inter-ministerial commission could be considered for an interim period. This commission would be accommodated either at the Ministry of Agriculture or in one of the CRDA, and would be responsible for, and have the authority to:

i. Manage and arbitrate the water allocations;

ii. Provide information on the key measure for real time water, and natural resource management; identify and prioritise investments, as well as critical space areas for managing the "hot spots";

iii. identify potential obstacles to cooperation and effective management, along with opportunities for overcoming these constraints;

iv. develop new policies for the management of the drainage basin; and

v. develop a transparent system for the processes responsible for decision making, which involve dialogues and discussions with the communities, the farmers and the operators.

vi. establish a systematic monitoring system, using environmental and social indicators in real time, to assist with the sustainable management of resources.

**Reduce the technical and financial losses of supply services for drinking water and irrigation water, including the potential to improve water management.** investments and institutional measures must be principally oriented towards three types of intervention:

- Rehabilitation of the networks for drinking water, sanitation and irrigation, based on a costed action plan which aims at targets for reducing technical and financial losses; structural changes in water management (incentives, governance, pricing that takes into account the demands of financial viability, conservation, and education of users), as well as choice of technology for greater efficiency in economic, financial and environmental terms; and

- Continuous improvement of management and performance indicators for the supply of drinking, sanitation and irrigation water.

**Focus on programming, investment efficiency and maximising environmental benefits in the rural wastewater sector.** At the present time the investments planned by the government and the international financial institutions in the wastewater sector do not cover rural areas, especially in municipalities with fewer than 4,000 inhabitants. This population has no access to improved sanitation, and worse still, the wastewater is not treated, and is discharged or infiltrated in the water bodies. It is important that:

- the Government takes drastic action on the regulatory and legal framework of sanitation in rural areas; and

- low-cost technologies are adopted and the investment, operating and maintenance costs are subsidized for a period of 5 years by the State.