

Case Study 2: Morocco

Boukhalef wastewater treatment plant and Tangier green space and golf course water reuse

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Acronyms

ABH	River Basin Agency
APDN	Northern Development Agency
PNE	National Water Plan
RADEEMA	Water and Electricity Distribution Authority of Marrakech

History and project justification

The Boukhalef Wastewater Treatment Plant (Boukhalef WWTP) was constructed to increase capacity in wastewater treatment and to provide irrigation water for green spaces in Tangier city. Operational since 2015, the plant was designed in the face of increasing deficits in water reserves at the Ibn Battouta Dam, which serves residents of the cities of Tangier and Assilah with drinking water. Treated wastewater can provide an additional water resource, particularly for irrigation purposes. This subsequently reduces pressure on conventional water resources. According to Amendis, this project will save nearly 3 million m³/year of water and improve the health and living environment of residents, and bring additional benefits for promoting tourism, for example, through the investment and development of green landscaped areas and golf courses around the city.

The Boukhalef WWTP covers a total area of 4.3 ha and is located in Gzenaya, an industrial zone on the border of the Free Zone of Tangier (Figure 2.1).

Before the construction of the Boukhalef WWTP, wastewater from Tangier city was discharged directly into the Mediterranean Sea after collection. Since 2015, when the plant became operational, domestic wastewater from the Rabat Road area, Boukhalef South, Gezenaya center, and the domestic and industrial effluents of Gezenaya and the Tangier Free Zone is treated there and then reused in irrigation projects.



FIGURE 2.1 Map showing location of the Boukhalef WWTP. WWTP Coordinates: 35.716954, -5.932413.
SOURCE: Google Earth.

Reuse case description at a glance

The Boukhalef WWTP started operations in 2015 and has a capacity of 10,700 m³/day. This capacity is anticipated to increase, after current expansion works, to 42,700 m³/day. The plant uses an activated sludge treatment system and treats the water to a tertiary level (Figure 2.2). The recycled water it produces is used to irrigate golf courses and municipal green spaces.

The project has been carried out in three phases:

The first phase started in 2015 with the commissioning of the Boukhalef WWTP, the laying of an 8 km distribution network and the installation of a 120 liters per second (L/s) pumping station to irrigate an area of 110 ha of green spaces at the Qatari Diar Golf Course.

The second phase, which started in 2019, saw the expansion of the reuse network toward the center of Tangier to irrigate municipal green spaces and the Tangier Golf Royal. In addition, two storage tanks with a total capacity of 6,000 m³ and a capacity discharge station at 120 L/s were constructed. A second tertiary treatment plant was also established, and 21.5 km of distribution network laid. The target of this phase was the irrigation of 141 ha. To date, 115 ha, including 70 ha for the Royal Golf Tangier, located in the Municipalities of Tangier and Gzenaya, are irrigated with recycled water from the plant.

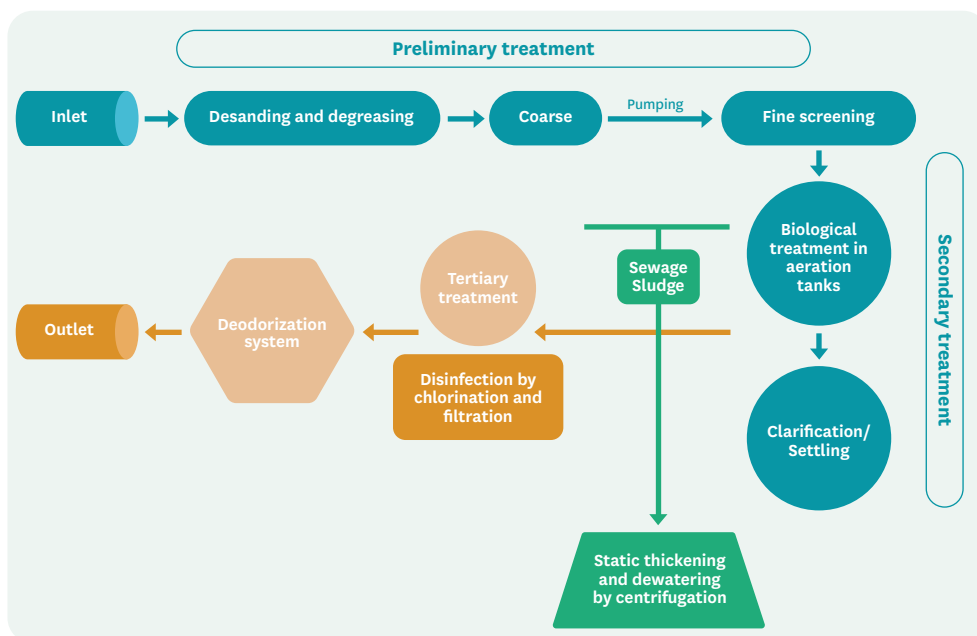


FIGURE 2.2 Boukhalef WWTP and water reuse system: Simplified schematic diagram.

SOURCE: B. Soudi.

The third phase, which is in progress, will increase the capacity of the Boukhalef WWTP to 42,700 m³/d and expand the irrigation area to 150 additional hectares across the rest of the city. Construction work for this expansion is in the final phase and a study to extend the transport and distribution network is almost complete.

National institutional and policy framework

The current policy framework in Morocco is supportive of this water reuse project, including its replication and scaling as part of a strong promotion of water reuse, which is included in many policies, plans and programs (the National Water Strategy, the National Water Plan, the National Shared Sanitation Plan and the Emergency Drinking Water Supply and Irrigation Program (2020–2027)). In addition, national integrated water resource management plans integrate reuse at the scale of river basins.

However, the governance of the project faces some difficulties (Figure 2.3), particularly in

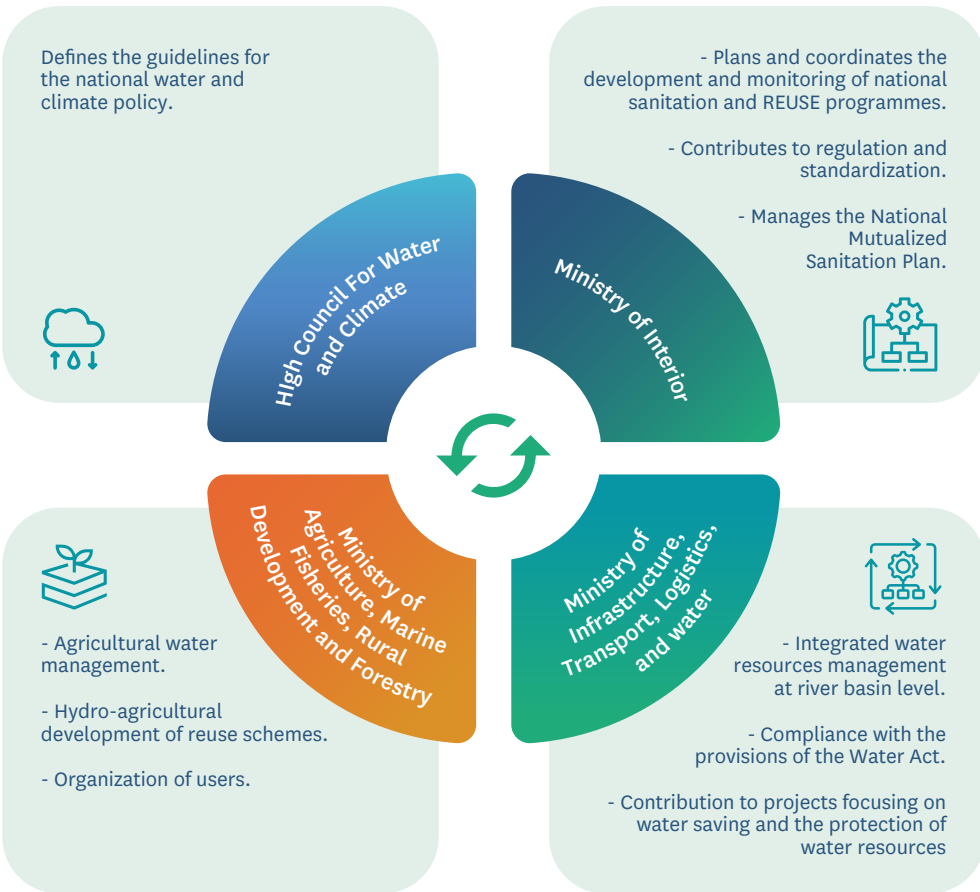


FIGURE 2.3 Key institutional players for wastewater treatment and reuse.

SOURCE: B. Soudi, Institute of Agronomy and Veterinary Medicine.

terms of intersectoral coordination and regulatory gaps. These include the definition of standards for sewage sludge recovery and the risk of non-financial viability of public partnership contracts agreed between the municipality and Amendis, the sanitation operator. From a technical point of view, these contracts do not clarify the sharing of responsibilities, in particular concerning the quality of the recycled water used to irrigate golf courses, which is prone to deterioration.

Other ministerial departments including the Ministry of Health and the Ministry of the Environment, as well as several water commissions, are also connected to this institutional scheme with territorial and regional representative entities including the National Office of Electricity and Drinking Water (ONEE-Water Branch), public service operators such as Amendis and private concessionaires.

Water recovery and reuse are also subject to regulatory compliance (Table 2.1).

TABLE 2.1 Regulatory texts relating to the recovery and management of wastewater in Morocco.

Law, decree or order	Arrangement
Decree n°2-05-1534 du 21 Chaoual 1426 (November 24, 2005) on the terms and conditions for the preparation and revision of the PDAIREs and the National Water Plan (PNE). Official Bulletin No. 5562 of 20/09/2007. Included in the new law 36-15.	<p>The preparation of the draft master plan for the integrated development of water resources (PDAIRE) is entrusted to the River Basin Agency (ABH) of each basin in consultation with the other stakeholders in the field of water.</p> <p>Among the components of the master plan are the plan of its financing and the action plan for monitoring its implementation.</p> <p>The draft of the National Water Plan (PNE) is drawn up by the Minister responsible for water in consultation with the other ministerial departments and institutions that are members of the Higher Council for Water and Climate under the conditions specified in numerous articles of the same Decree.</p>
Decree n°2-05-1533 du 14 Moharram 1427 (13 February 2006) on autonomous sanitation. Official Bulletin No. 5404 of 16/03/2006 (Article 4).	Any installation of an autonomous sanitation system in rural areas is to be declared to the technical services of the municipality.
Decree n°2-97-224 du 21 Joumada II 1418 (October 1997) laying down the conditions for the artificial accumulation of water. Official Bulletin No. 4532 of 06/11/1997.	Articles 2 and 3: Artificial accumulation of raw wastewater shall be permitted only if it is an integral part of a system for treating such water, approved by the water basin agency concerned. The application for authorization is addressed to the corresponding ABH.
Decree n°2-97-875 du 6 Chaoual 1418 (04 February 1998) on the use of wastewater. Official Bulletin No. 4558 of 05/02/1998 (under revision)	<p>It is forbidden to use wastewater unless it is declared treated in accordance with the standards.</p> <p>It is also forbidden to use wastewater, even if treated, for drinking, preparation, packaging or preservation of products or foodstuffs.</p>
Articles 1; 2; 10; 11 and 12.	The conditions of application and the criteria used to benefit from the financial assistance are regulated and the application is filed with the ABH.
Joint Order n°1276-01 du 10 Chaabane 1423 (17 October 2002) setting standards for the quality of water intended for irrigation. OB No. 5062 of 05/12/2002 (under revision).	Treated wastewater whose reuse is thus authorized must meet the quality standards set by this Order laying down the quality standards for water intended for irrigation.

SOURCE: B. Soudi, Institute of Agronomy and Veterinary Medicine.

Stakeholders involved and management model

The management model for the use of recycled water from the Boukhalef WWTP for golf courses and green spaces operates within a partnership framework in conjunction with other municipalities including Fnideq, Tetouan and M'diq in the north of Morocco.

A formal agreement establishes the partnership and cooperation between the signatory parties (Figure 2.4), by defining their roles and responsibilities, in particular with regard to (i) financing and implementation of projects, (ii) monitoring of achievements and (iii) monitoring the quality of treated wastewater and the operating and monitoring of projects.

The responsibilities of the key players and their functional relationships are outlined below:

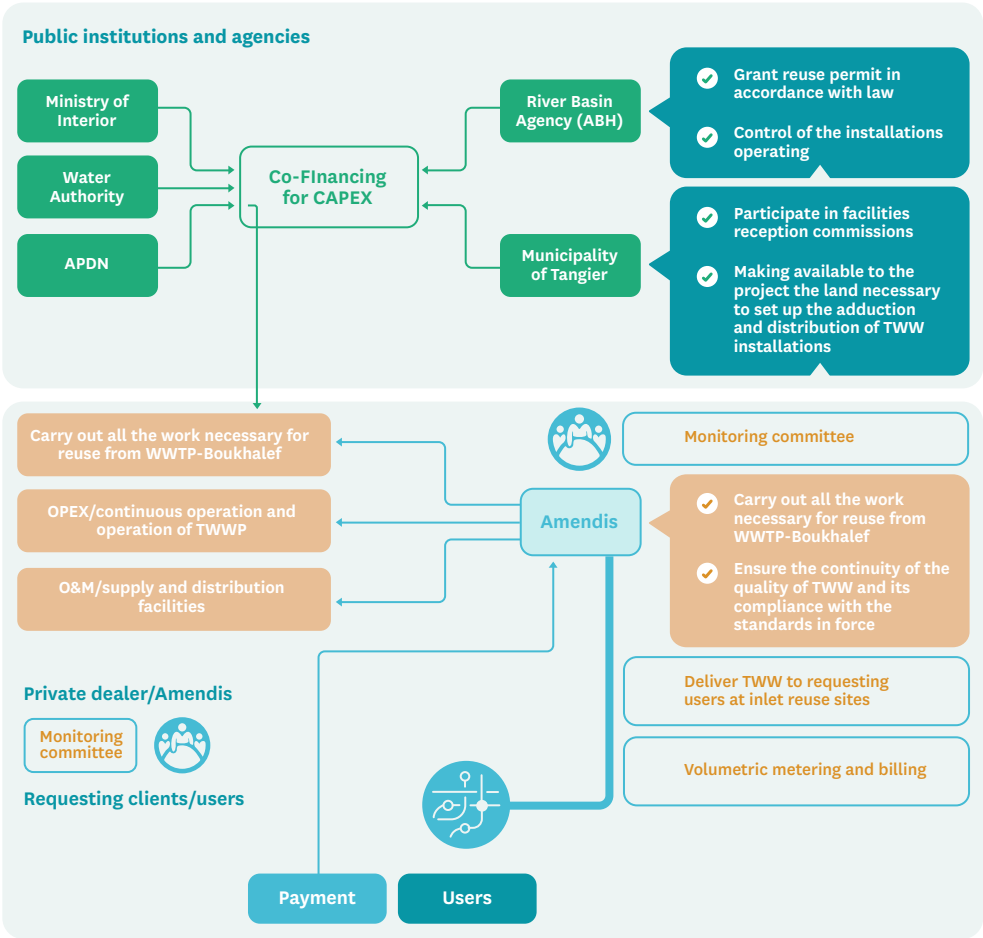


FIGURE 2.4 Management model of Buokhalef wastewater treatment plant and Tangier green spaces and golf courses reuse project.

SOURCE: B. Soudi, Institute of Agronomy and Veterinary Medicine.

NOTES: Northern Promotion and Development Agency (ADPN), Capital Expenditure (CAPEX), Operational Expenditure (OPEX), Operations and Management (O&M), Treated wastewater (TWW).

- The ABH provides financial support and permits for water reuse motivated by the economy and the protection of water resources in accordance with the law.
- The municipality of Tangier provides the land and financial contribution for the construction of the wastewater treatment plant.
- The Ministry of the Interior, the Water Authority and the Northern Development Agency (APDN) invest the capital expenditure (CAPEX).
- Amendis, a private entity, manages necessary works and installations, ensures the consistency of the quality of the treated wastewater intended for reuse, covers the operating expenses (OPEX) and maintenance and delivers recycled water to end-users at USD 0.27/m³.
- A monitoring committee monitors compliance with the terms of the partnership contract and the overall operation of the treatment and reuse system.

Funding and financial outlook and cost recovery

Boukhalef WWTP's operation and maintenance costs are around USD 0.088 million (MAD 0.88 million)/year, which includes USD 0.033 million for maintenance and USD 0.27 million for electricity. Table 2.2 summarizes data on CAPEX, OPEX and cost recovery.

TABLE 2.2 Funding and financial outlook and cost recovery.

Segments REUSE value chain	Construction and equipment services (description and dimensions)	
Description	Tertiary treatment plant with a capacity of 10,700 m ³ /d (2015 until present). Expansion to 42,700 m ³ /day	
Who delivers?	Amendis as delegated private concessionaire from the municipality (contracting with specialized companies)	
Financing source contribution to the initial investment	The municipality of Tangier provides the construction land	
	Stakeholders	Co-finance (USD Millions)
	Municipality of Tangier	1.1
	Ministry of Interior	1.1
	Water Authority	2.53
	Basin River Agency (ABH)	0.22
	Agency for the Promotion and Economic and Social Development of the Northern Prefectures of the Kingdom (APDN)	0.33
	Regional Council of Tangier-Tetouan-Al Hoceima Tangier-Tetouan-Al Hoceima	0.77
	Total	6.05
Cost recovery	Sanitation tax integrated into the Drinking Water and Electricity Bill OPEX related to tertiary and complementary treatment.	
	Selling price to the golf promoters: USD 0.27/m ³	
Entity in charge of OPEX	Amendis	
O&M	Amendis	

SOURCE: B. Souidi, Institute of Agronomy and Veterinary Medicine (on the basis of data provided by AMENDIS). NOTES: Capital Expenditure (CAPEX), Operations and Management (O&M), Operating Expenditure (OPEX).

Socioeconomic, health and environmental benefits and impacts

Currently, the reuse system has not generated much employment in the long term although Amendis consider it likely this will change. In terms of the design and implementation of the wastewater treatment plant and reuse system, jobs have been created for companies engaged in construction work, but Amendis are not able to provide data on this. In terms of tourism, the city of Tangier is one of the cities most frequented by recreational and seaside tourists in Morocco. Wastewater treatment and reuse of the recycled water makes it possible to improve the attractiveness of the city through the expansion of green spaces and at the golf courses that benefit from the project.

The collection and processing of wastewater has greatly improved the local environment compared to the pre-project situation and reuse is having a very positive impact in terms of reducing groundwater and other water uses, saving 3 million m³/year.

Gender equality

In a recent push, Amendis has been promoting gender diversity and equality, in particular through its recruitment policies. This strategy has brought results. In 2016, more than 18% of the supervisors employed at the Boukhalef WWTP and in its administration were women. In 2018, that number rose to more than 20%. Amendis is also encouraging more women to enter the technical field (Amendis 2019), particularly as the proportion of women in technical and engineering training schools is higher than that of men and their skills are equal.

Resilience to COVID-19

Overall, the impact of the pandemic on the project was limited. Boukhalef WWTP uses advanced technology and different levels of treatment that makes it possible to eliminate any probability of the virus being present in the treated wastewater. Also, treated wastewater goes through a final stage of tertiary treatment specific to reuse, and ultimately, chlorine disinfection, which ensures the destruction of any living organism before the water enters the network. Quality tests and monitoring are also carried out regularly.

Scalability and replicability potential

The Tangier project is already being scaled up in the northern region of Morocco. As mentioned earlier, it is part of a cluster of projects that are managed under the same partnership agreement. The replication and scaling up of this type of project are driven by the National Water Strategy and the National Water Plan, which set out a roadmap to promoting the reuse of treated wastewater to alleviate pressure on conventional water resources and build resilience to climate change. Portability is ensured by the good documentation of technologies and by the success of public-private partnership contracts between Amendis and the municipality of Tangier. Also, the extension of green spaces and the establishment of new golf courses in the city of Tangier and its surroundings will absorb the expected increases in the volumes of treated wastewater through reuse for irrigation.

SWOT analysis

Table 2.3 summarizes the strengths and weaknesses, opportunities and threats (SWOT) of the Boukhalef WWTP and Tangier green spaces and golf courses reuse project.

TABLE 2.3 Boukhalef WWTP and Tangier green spaces and golf courses reuse project: SWOT analysis.

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	STRENGTHS <ul style="list-style-type: none">■ Competence and professionalism of Amendis.■ Financial contributions from partners in the reuse project as a whole.■ Funding under the National Shared Sanitation Plan.■ Financial solvency of wastewater reuse.■ Strong mobilization of actors at the regional level.■ An innovative project in the Mediterranean region.■ Strong support of Tangier Municipality for green spaces in the city and tourist locations.	WEAKNESSES <ul style="list-style-type: none">■ Unclear responsibility for the quality of treated wastewater within golf courses.■ The total area of green spaces has risen to 283 ha, which is disproportionate in its distribution at the district level.■ Despite best efforts, a good number of gardens and green spaces within certain districts remain very poorly maintained.■ Lack of awareness and respect for green spaces by citizens resulting in a low level of cleanliness.■ Lack of staff to maintain green landscapes.
EXTERNAL FACTORS ATTRIBUTES OF THE ENVIRONMENT	OPPORTUNITIES <ul style="list-style-type: none">■ Objectives to promote reuse in policies, plans and programs.■ Water scarcity due to climate change makes a great opportunity for the fast deployment of water reuse in North Morocco.	THREATS <ul style="list-style-type: none">■ Risk of financial non-viability of the project.■ The reluctance of golf course developers and users of conventional water because the conventional water is cheap or free.

SOURCE: B. Soudi, Institute of Agronomy and Veterinary Medicine.

Key factors for success along the project and lessons learned

During the design, construction and operation of the project, key factors of success include:

- Implementation efficiency in terms of the quality of the treatment and distribution works, due to the technical and managerial competence of Amendis. Collection, treatment and pollution remediation targets were met during the period 2002–2020.
- Amendis has finalized and scaled up the required level of treatment and has set up the distribution network that transports the treated wastewater to the reuse sites.
- In comparison with agricultural recovery, this reuse model is viable because it involves a logic of remuneration with solvent users, which contributes irrefutably to cost recovery.
- The current expansion of the WWTP system is a relevant indicator of the scalability and sustainability of the project.

Methods and resources

The methodology adopted to carry out this water reuse case study includes:

- Review of technical documents.
- Interviews with institutional heads from the national water authority (Jaouher Touria and Houda Bilrha from the Water Department; Abdelhamid Benabdelfadel from the ABH).
- Interviews with managers at the Boukhalef Wastewater Treatment Plant and Water Reuse project (Thomas Fer, Water & Sanitation Director and Imane El Hatimi, Coordinator of Plural Performance and Digital Transformation, Amendis – the water and electricity operator for northern regions of Morocco).

In addition, the author wrote an e-mail to Thomas Fer, the project manager at Amendis, outlining the project's background and requesting the validation of information and data provided in the template, and to provide missing data. This triangulation approach combined with the effective participation of Amendis in providing data for this water reuse case has made it possible to complete the template almost fully.

Additional resources used in gathering data for this study include:

AFD-Ministère de l'Intérieur: Assistance technique à la Direction des Réseaux Public Locaux du Ministère de l'Intérieur, pour la mise en œuvre du Programme d'Appui Institutionnel au Secteur de l'Assainissement au Maroc (PAISAM), dans le cadre d'une subvention de la FIV d'un montant de deux millions d'euros en gestion déléguée à l'AFD a été octroyée pour le financement dudit PAISAM.

Amendis. 2019. *AMENDIS MAG* March 2019, Issue 5. Morocco. Amendis. https://www.amendis.ma/sites/g/files/dvc3316/files/document/2019/04/MG_Ndeg5_Mars_2019_VF.pdf

Amendis. 2021. Étude d'extension du système de réutilisation des eaux traitées de la STEP Boukhalef pour arroser les espaces verts de la ville de Tanger. Étude d'Avant – Projet – Sommaire.

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- Ziyad, A. 2021. *River basin master plans: planning and water management tools to identify hydraulic projects*. Paper presented at AFRICA 2017: Water storage and hydropower development for Africa, March 14–16, 2017, Marrakech, Morocco.

National documents were also consulted including the National Sanitation Plan (2009), the National Water Plan (2018) and the National Mutualized Sanitation Plan (2017).