



WP4. IMPROVE USE EFFICIENCY OF NON- CONVENTIONAL WATER IN AGRICULTURE

Output 4.2. Living Labs equipped
with TWW Irrigation trains adapted
to local contexts

A 4.2.1 Design, equipment and
operationalization of the demo sites:
Choutrana II, Borj Touil, Beni Hassen,
Tunisia

Responsible partner: ONAS

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ABBREVIATIONS AND ACRONYMS

Acronym	Description
AVFA	Agence de la vulgarisation et de la formation agricoles
CRDA	Commissariat Régional au Développement Agricole
ONAS	Office National de l'Assainissement
TWW	Treated Wastewater
WB	World Bank
WP	Work Package
WWTP	Wastewater Treatment plant

1. BACKGROUND

This technical report has been written in the context of the MENAWARA project on *Non-conventional Water Re-use in Agriculture in Mediterranean countries*.

The joint challenges of the MENAWARA project consist in providing additional resources by recycling drainage and wastewater, rationalizing water use practices and setting operational governance models in line with national and international plans. The project is designed to enhance access to water through the treatment of wastewater to be re-used as complementary irrigation and to strengthen the capacity of governmental institutions, non-state actors operating in the sector, technicians, and farmers.

The report reports the activities carried out in the fourth Work Package (WP4) of the MENAWARA project and, in particular, is related to the **Output 4. 2 “Living Labs equipped with TWW Irrigation trains adapted to local contexts”** and **Activity 4.2.1 “Design, equipment and operationalization of the demo sites”** as described in infographic below (Fig. 1).

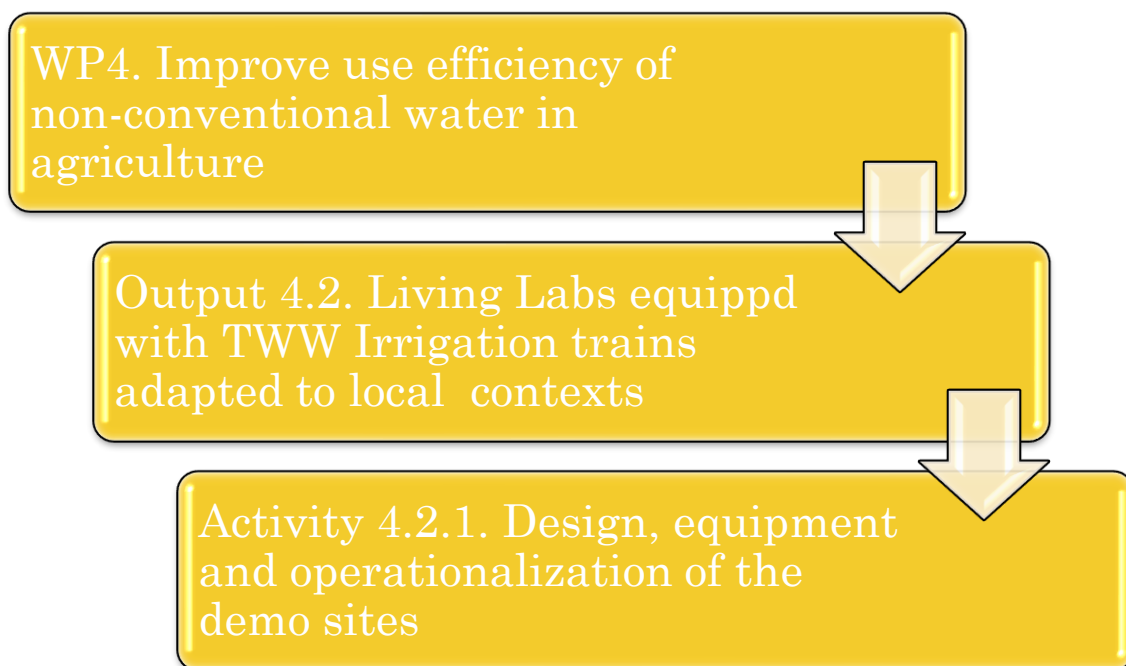


Figure 1. Infographic on the context of this technical report.

More specifically the output 4.2 is described as follows: “Based on the findings of output 4.1, the irrigation trains combining technologies and techniques are identified and implemented in the intervention areas and their operative performance and their impact on water use efficiency and productivity on health and on groundwater are monitored.”

This document details the technical aspects of the irrigation trains realised in Tunisia inside the property of the WWTP of Choutrana II and in the Borj Touil area including the GDA Sidi Amor. In the Beni Hassen site, the irrigated area that surrounds the WWTP was considered but no new and/or rehabilitation intervention on the irrigation network was implemented. These interventions were realised under the Activity 4.2.1 “Design, equipment and operationalization of the demo sites”. It is worth to mention that the activity has been carried out by ONAS in collaboration with the GDA Sidi Amor, the CRDA of Ariana and Beni Hassen.

The document is structured as follows: i) an introduction and general overview of the areas of intervention (section 2); ii) the designed irrigation trains supplied with improved TWW (section 3); iii) the establishment and operationalization of the Living Labs (section 4); and vii) some concluding remarks (section 5).

2. AREAS OF INTERVENTION

The interventions implemented in Tunisia within the activities of the MENAWARA project include 3 sites: Choutrana II, Borj Touil and Beni Hassen. The intervention site of Beni Hassen (Monastir) replaced the initially proposed sites of Kelibia and Korba, after having been cancelled in the major amendment approved by the Managing Authority on August 23rd, 2022. In the following, a short description of each area is reported.

Choutrana II is a part of the Choutrana WWTP which is located in a flat swampy area, 20 km northward from the centre of Tunis. It gathers the sewerage system of Tunis city, serving more than 1 million inhab. eq., occupying a large surface of 40 ha. The outflow from the tertiary treatment line implemented within the activity of the WP3 supplies a drip irrigation network in an experimental irrigated garden of 0.6 ha, named the Living lab (Fig. 2).



Figure 2. Location of the Choutrana II intervention site

The Borj Touil intervention area is located in the Governorate of Ariana, northward from Tunis. TWW is conveyed to Borj Touil scheme from Choutrana plant. The GDA Sidi Amor has its own treatment plant, which, by gravity, receives 500-600 m³/day from an accumulation tank (160,000

m3). The outflow is pumped to supply the fields inside the GDA and to the farms located down the hill in the Borj Touil plain (Fig. 3). The main crops in Borj Touil are fodder and trees: furrow and drip irrigation are practiced. There are 500-600 ha under modernization. The target is 3,000 ha.

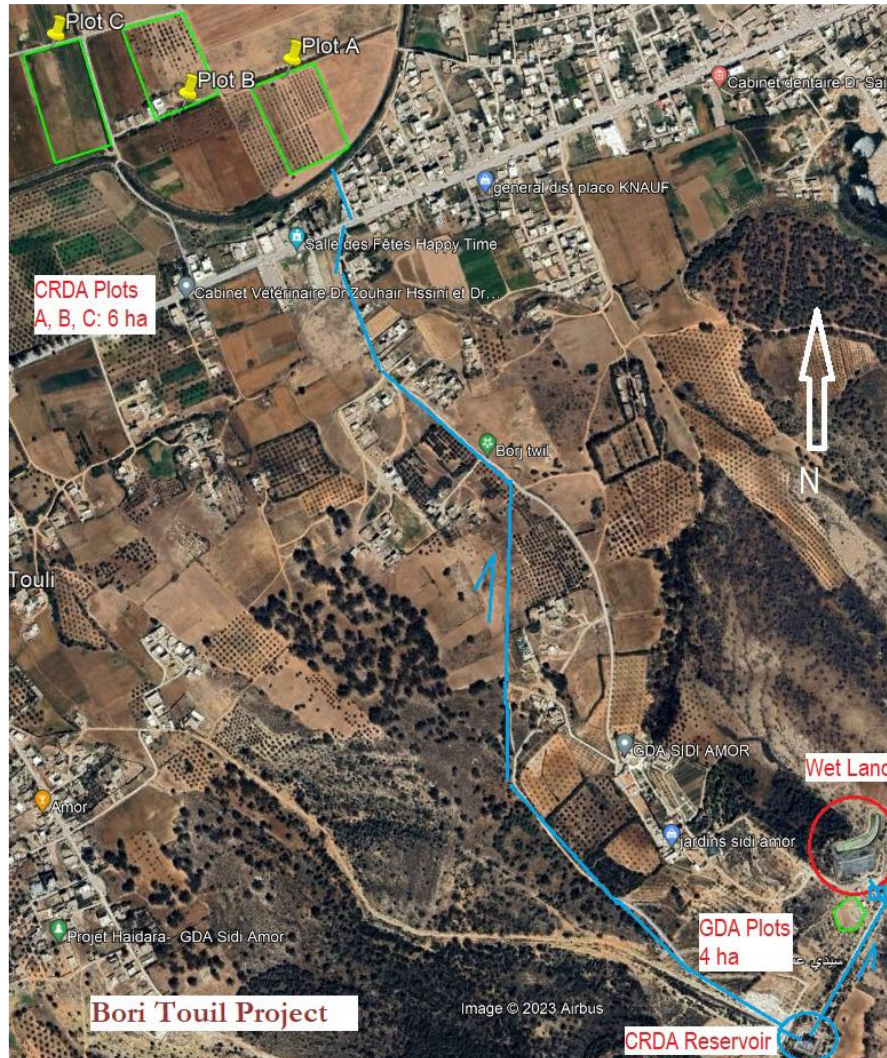


Figure 3. Location of the Borj Touil intervention area

The Beni Hassen Municipality is located 18 km southward of Monastir city, house of the ONAS directorate premises. Located in the flat rural area of the arid Tunisian Sahel, the main economic resource is the cultivation of the olive trees. Due to the lack of surface water resources and the high level of salinity of the groundwater ($> 6-7$ g/l), it is a rainfed area that is suffering nowadays for the severe rainfall reduction caused by the climate change effects. According to the Country Water Policy, in order to (partially) alleviate the shortage of water, the utilization of the TWW is incentivized by

the Ministry of Agriculture. Nearby the Beni Hassen WWTP, the CRDA of Monastir realized, in 2017, a piped irrigation networks serving a command area of 60 ha, at an elevation of around 40 m asl. Within this area, only a part of the farmers, owning 30 ha (50%), accepted to irrigate their plots with the TWW. The WWTP managed by ONAS is located 2.6 km NNW from the centre of the town of Beni Hassen. The MENAWARA intervention consisted of the rehabilitation of this tertiary plant (sand filter + UV disinfection) and the realization of a RCC tank of 100 m³ for improving the functioning of the CRDA pumping station at the outlet of the WWTP feeding the d/s piped irrigation network (Fig. 4).

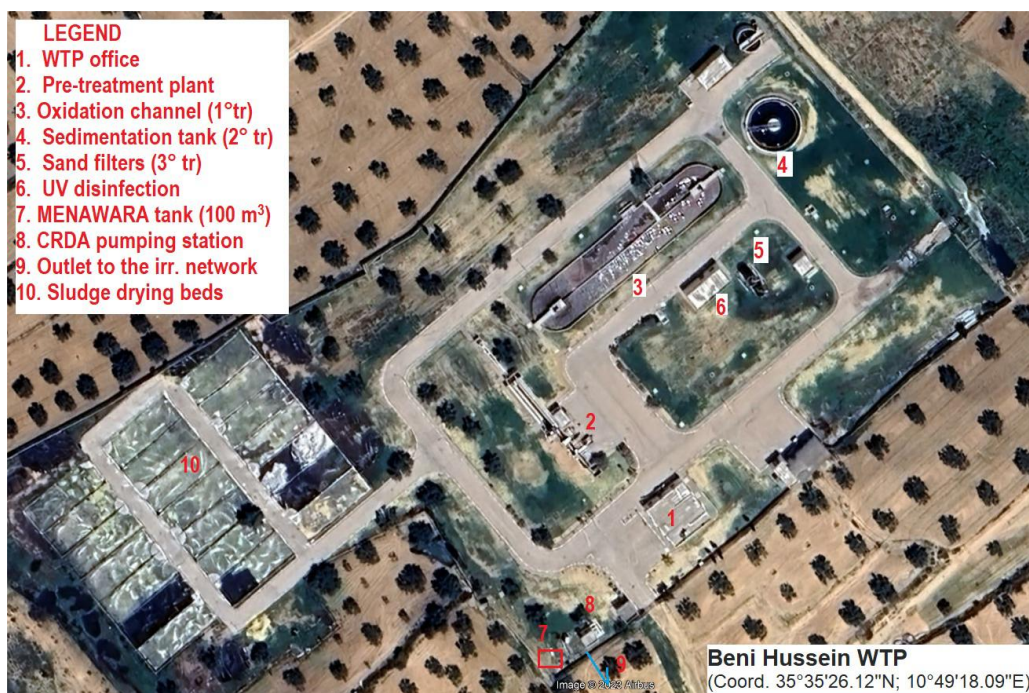


Figure 4. Location of the Beni Hassen intervention site

3. DESIGN OF THE IRRIGATION TRAIN

3.1. IRRIGATION TRAIN IN CHOUTRANA II

The irrigation train implemented in the Choutrana II site, inside the WWTP, and supplied by the outflow from the tertiary treatment system, consists of a drip system over an area of 0.6 which include 0.2 ha of a new plot while in the remaining part a rehabilitation of an already existing system was carried out (Fig. 5).



Figure 5. Scheme of the irrigation train and crops in the Choutrana II site

This irrigation system made it possible to show to students, researchers, the *Agence de la vulgarisation et de la formation agricoles AVFA* and other institutions the good scientific and economic results that can be achieved by using TWW through this kind irrigation system.

Several vegetable crops were planted and irrigated with the improved quality TWW such as tomato, pepper, bean, barley, sunflower (Fig. 6) and ornamental plants such as rosemary, lavender, thyme, geranium (Fig. 7)

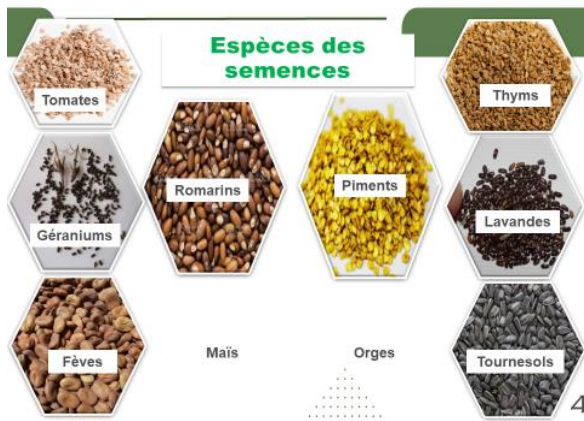


Figure 6. Vegetable crops in the Choutrana II site



Figure 7. Ornamental plants in the Choutrana II site

3.2. IRRIGATION TRAIN IN BORJ TOUIL

In compliance with WP4, a total surface of 10 ha was affected by irrigation works:

- 4 ha in the area managed by the GDA of Sidi Amor where a new irrigation system was implemented in 1.5 ha while the remaining 2.5 ha were affected by a rehabilitation intervention;
- 6 ha of the fertile below plain managed by the CRDA of Ariana where the irrigation system was rehabilitated.

In the GDA Sidi Amor area, a pumping station was installed for serving 4 ha equipped with drip irrigation systems on the hilly area close to the CWs site (Fig. 8), cultivated with olive trees. The soil has a rocky skeleton, suitable only for that cultivation.



Figure 8. The 4 ha equipped with the drip irrigation system in the GDA Sidi Amor area

The other 6 ha owned by 3 farmers are located in the Borj Touil plain, cultivated with olive trees and/or fodder; they are part of the CRDA irrigation littoral scheme (Fig. 9). This area was already equipped with fully pressurized network and on-farm localized systems, part of a large irrigation scheme financed by the World Bank (WB).

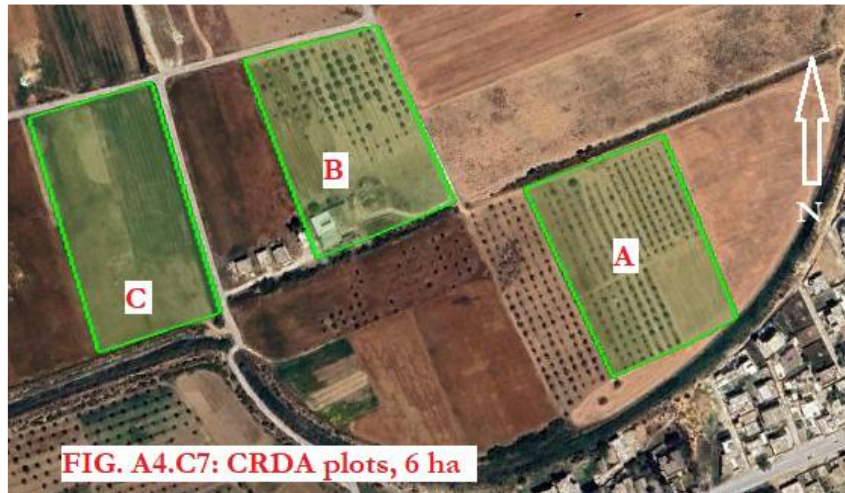


Figure 9. The 6 ha equipped with the new irrigation train in the CRDA area

Unfortunately, the on-farm drip irrigation systems, despite the presence of sand filters (Fig. 10), were clogged and out of order since several years. MENAWARA accepted the CRDA proposal to rehabilitate these networks in this small portion of 6 ha only. Enhanced surface irrigation has been implemented including the installation of a 200 ml long pipe in uniformly perforated HDPE PN6075 (calibrated nozzles) to improve the irrigation efficiency at the plot level which may lead to additional water savings. Pressurized networks were then laid down with some isolated hydrants spread in the field (Figs. 11, 12). The installation of this irrigation system has been monitored by the competent services of the CRDA of Ariana.



Figure 10. The CRDA Plot A with the on-farm sand filter

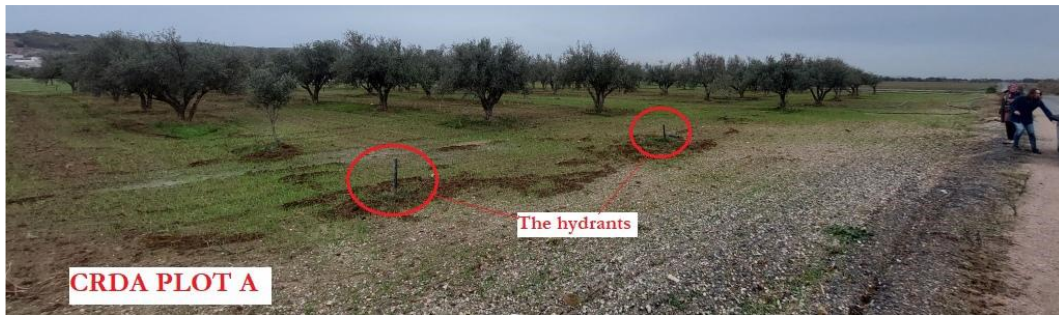


Figure 11. The CRDA Plot A with the hydrants



Figure 12. The CRDA Plot B with the hydrants

3.3. IRRIGATION TRAIN IN BENI HASSEN

MENAWARA did not foresee new installation or rehabilitation of an irrigation system because a piped irrigation network serving a command area of 60 ha has already been implemented by the CRDA in 2017. For this reason, the objective of the project in this area was only to rehabilitate the tertiary treatment system (sand filter + UV) and realize the RCC tank in order to supply the existing irrigation network with improved quality TWW. Indeed, the farmers who previously accepted the proposal from the CRDA to start irrigating the olive trees with TWW to cope the issues related to water scarcity due to decreasing trend of the precipitation in the last years, stated to be not really satisfied for the quality of TWW currently supplied by the WWTP of Beni Hassen, claiming as well for the quantity of the distributed water that is not sufficient for covering the crop requirements (Fig. 13). In the past years, many of them searched water resources digging wells at

different deepness but the aquifer in many cases was too much salty (up to 8 g/l).

Despite this not really enthusiastic situation, with the completion of the MENAWARA project, the improvement of the TWW quality is expected through tertiary treatment line rehabilitation, while the flow quantity will be increased for a better functioning of the CRDA pumping station through the new 100 m³ compensation tank, to satisfy at least the demand of the farmers owning 30 ha (50% of the total irrigated area), who accepted to irrigate their plots with the TWW. It's important to point out that 4 farmers at the moment, covering 12 ha of the 60 (20%), has created a Group de developement Agricole (GDA), and, thanks to a temporary law issued by the Government in June 2023, started irrigated their land with TWW coming from the secondary treatment waiting for the installment of UV lamp whose electronic cards were received on in January 2024 (competition of work: February 2024).



Figure 13. Farmer who started to use TWW to irrigate the olive trees in Beni Hassen

4. ESTABLISHMENT AND OPERATIONALIZATION OF THE LIVING LAB

A Living Lab has been established for the different intervention sites of Choutrana II, Sidi Amour, Beni Hassen and Korba and Kelibia previously. The living lab foresaw the participation of different stakeholders from the quadruple helix that were able to meet to co-design solutions adopted to the needs of users, in line with the fit to purpose approach followed along the project. Irrigation trains have been then adapted to the context and needs including solutions that could be accepted by all the stakeholders. In particular, the irrigation trains proposed by CIHEAM BARI for the CRDA fields in Sidi Amour had to be changed following the negative past experience of farmers who refused new drip irrigation systems preferring to adopt the traditional surface/furrow method that was, however, enhanced. What happened allowed the partners to be more aware of the fact that they had adopted the best and shared approach in choosing the involvement of the interested parties who would be the final beneficiaries. And this is the added value of similar actions, what makes the project sustainable over time. Even though the implementation of works had to be cancelled in Korba and Kelibia, the interest on those areas was not abandoned and farmers, technicians and other stakeholders from the areas had the opportunity to participate in exchange, training experiences and roundtables.

On March 1st, 2023 an important event has been organized in the GDA of Sidi Amour gathering researchers, engineers, and local stakeholders, called to share their experiences after two field visits to the sites of Choutrana II and Sidi Amor.



The initiative highlighted the critical situation of water scarcity in the country and the need to prepare for a range of different scenarios, including working on non-conventional water sources. The info day was the occasion to outline a future vision in the context of water scarcity adaptation and mitigation towards the creation of a consortium of stakeholders to deal with the issue. While each institute works independently, they confirmed their willingness in leveraging the added value of shared goals. This was the first time an institute like ONAS had the capacity, network, and drive to take the project to the following level. Researchers, farmers, technicians from private and public sectors as well as decision makers were very motivated after visiting the MENAWARA sites of Choutrana and Sidi Amor, realising that there is a tangible impact of the project in the territory.

In Choutrana II, the intervention made it possible to consolidate cultural, scientific and know-how exchanges among researchers, research institutes, NGOs, students and farmers. Indeed, the number of visitors easily exceeded 400 visitors of different categories and is reflected in partnership initiatives such as that with the Economic Department of the United States Embassy in Tunisia and USAID.

It should be noted that students have already started to work in their final thesis, namely 3 degree projects were carried out in 2023 by students from Tunisia and Sub-Saharan countries affiliated to the following public and private universities:

1. ECOLE POLYTECHNIQUE UNIVERSITE CENTRALE TUNIS:

Jeans Bosco Miterant Moussosso Makenda (Gabon), Chemical engineering

Subject: Tertiary treatment of wastewater and their valorization in the field of agriculture.

2. FREE UNIVERSITY OF TUNIS “ULT”:

Aichettou Elhassen (Mauritania), Chemical engineering

Subject: Valorization of wastewater from the Choutrana station by bio adsorbent “CORN Stalk”.

3. NATIONAL INSTITUTE OF APPLIED SCIENCES AND TECHNOLOGY “INSAT”:

Oumaima Azizi (Tunisia), Industrial chemistry engineering



Subject: Optimization and commissioning of the tertiary treatment unit of the Choutrana wastewater treatment plant with a view to reusing treated wastewater.

In Sidi Amor, the role of GDA in training and raising awareness was further consolidated and the improvement of TWW following the MENAWARA intervention allowed to develop further projects taking TWW to the following step making it possible to focus on Aquaponics and Hydroponics after further treatments (TUNGER Waterretune project).



Figure 14. Project Waterretune explained to Jordanian and Palestinian participants of the interchange experience in Tunis (12-14/06/2023)

5. CONCLUSION

The Tunisian intervention sites became Living Labs in the MENAWARA project, characterized by co-creation, experimentation and evaluation of innovative products in the wastewater treatment and reuse for irrigation of different crops such as olive trees, fodder, vegetable crops and ornamental plants. In the Beni Hassen intervention area which replaced, in 2022, after 3 years of project, the previous selected areas of Korba and Kelibia, the rehabilitation works of the tertiary treatment line were completed only in February 2024. For this reason, ONAS, in collaboration with the CRDA of Monastir, was not able to supply the improved TWW to the existing irrigation network by the end of the MENAWARA project to irrigate 30 ha of olive trees owned by the farmers who have already accepted to reuse TWW, but only 12 ha with secondary treated water benefitting from a law issued in June 2023 to challenge the extreme draught period. Starting from the next irrigation season all 30 ha will be irrigate.

Beni Hassen represents potentially a very important area for the reuse of TWW in agriculture, considering that the existing irrigation network covers a total surface of 60 ha and the most part of the farmers have understood that TWW represent the only possible water resource available in a context of water scarcity that characterizes this area, due to the climate change impacts as showed during the interchange experience in Jordan they participated in.

The Living Lab has been focused on the user, operating in a territorial context and involving the stakeholders of the quintuple helix (administration, academia, companies, farmers and final users and environment), by multiple field visits and training activities on the field,

Irrigation systems installed in the intervention sites and supplied with TWW are technical solution, which could be replicated in other rural areas in the Mediterranean Region where water sources are also scarce or not accessible.

The field visits and training have positively impacted on the knowledge of different stakeholders and has raised on field discussions that are crucial to strengthen the knowledge not only of the farmers but of the rest of stakeholders in the subject.