Contract no. **688320**

MADFORWATER

DevelopMent AnD application of integrated technological and management solutions FOR wasteWATER treatment and efficient reuse in agriculture tailored to the needs of Mediterranean African Countries

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1 Introduction

This deliverable is relative to Task 7.3 - Stakeholder advisory board periodic consultation workshops, and summarises the main activities developed during those workshops and the most relevant outcomes, in the framework of the MADFORWATER project. To provide a good context, the current deliverable also includes a recap of Task 7.1 - Stakeholder mapping & analysis (M1-12), already reported in the confidential Deliverable 7.1 "Report on stakeholder analysis and mapping".

1.1 Definition of stakeholder

The first step for stakeholder participation is to define who the stakeholders are. Definitions of a stakeholder can vary widely. There are broad, more inclusive definitions such as "anyone who might be involved in or impacted by the project" or "any person, group, or organization that can place a claim on the project partners' attention, resources, or output, or is affected by that output". Also, more precise definitions can be used, such as "those individuals or groups who depend on the project to fulfil their goals and on whom, in turn, the project depends." For this analysis, a stakeholder is defined as a person or an organization (physical or moral person in legal terms), which might be involved in or impacted by the project. The organization perspective is chosen, because in the end any formalized interaction (e.g. collaboration) between MADFORWATER and stakeholders will always take place on organization level, even if this interaction is initiated by individual representatives of this organization. However, individual stakeholders cannot engage with the MADFORWATER project without being supported by the organization they belong to. That's why the stakeholder analysis will identify the position of stakeholders on organization level, by asking individual members of organizations what they think the position of their organization is towards the MADFORWATER project.

1.2 The MADFORWATER approach

MADFORWATER is characterized by a participatory approach, mainly ensured by the involvement of relevant stakeholders from Mediterranean African Countries (MACs). The involvement of those stakeholders is guaranteed in two ways: through the creation of a Stakeholder Advisory Board of the MACs involved (MAC-SAB), and through the development of several workshops at different stages of the project.

The participatory approach of MADFORWATER is characterized by a strong involvement of MAC-SAB members, in the evaluation of the developed technologies, water management strategies and policy recommendations, with a specific attention to gender equality. To guarantee this, an initial questionnaire and several Stakeholder Consultation Workshops (hereinafter SCWs) were developed at different stages of the project. The aim of these SCWs were various:

1. Identify the relevant stakeholders through an initial stakeholder mapping.
2. Collect the initial inputs on the gaps and needs in terms of adaptation to the local context of WW treatment and irrigation technologies.
3. Provide a mid-term evaluation of the suitability for the local context of the technologies to be scaled up and of the proposed tools for the analysis of water vulnerability, and a final validation of the proposed strategies, economic instruments and policies in the field

of water management, so as to produce tools with a high potential to lead to an effective and widespread implementation in the target MACs.

4. Inform relevant MAC stakeholders on the potential of the MADFORWATER water vulnerability tools, technologies, strategies and recommendations in support to policy, so as to increase the long-term impact of the project.

A total of 5 SCWs were developed during the lifespan of MADFORWATER:

- Initial SCWs. A total of 3 SWCs, one per target MAC country, were carried out during the first months of the project. Those workshops were used to (i) develop an initial stakeholder mapping; (ii) to identify the initial perception of the local stakeholders about the wastewater treatments and irrigation technologies proposed by MADFORWATER; (iii), identify the key barriers and driver for wastewater reuse for irrigation. In the case of Egypt, the workshop was only focused on stakeholder mapping:
  - Egypt – Cairo, November 2016 - initial stakeholder mapping
  - Morocco – Agadir, December 2016 - initial stakeholder mapping and group work
  - Tunisia – Tunis, May 2017 - initial stakeholder mapping and group work
- Middle SCW, Tunis, May 2018. This session was mainly focused on the evaluation of effective/suitable solutions for the treatment of several effluents (municipal, olive mill and textile) and for irrigation with treated effluents. A specific session on how to address the key barriers previously identified during the initial SCWs was also developed.
- Final SCW, Cairo, April 2019. A dedicated session entitled "Opportunities and challenges for intensifying agricultural reuse of treated wastewater in the NENA region" took place during the conference organised by FAO "Near East and North Africa Land and Water Days 2019".

Further information about the SCWs, including the most relevant outcomes can be found in the following sections.

2 Stakeholder mapping

A stakeholder mapping was conducted in order to (i) identify other stakeholders in addition to those included in the SAB during proposal preparation, (ii) create a large database of MAC stakeholders that were periodically informed about the main project outcomes, and (iii) map the stakeholder community so as to develop dissemination and communication activities tailored for the single stakeholder groups.

The identified stakeholders were categorized according to their characteristics, interests, attitude, influence and relevant knowledge for the project with the aim of addressing each category using the most appropriate language and communication channels. The outcome of the stakeholder analysis was used to develop a dedicated dissemination and communication strategy (Task 7.2).

The biggest challenge in stakeholder engagement in MADFORWATER is that this is a transdisciplinary project across 2 major topics: wastewater treatment and irrigation. Most experts do not have a transdisciplinary experience because they expand their knowledge around one given area of interest. Consequently, MADFORWATER activities needs to rely on local experts from several sectors of expertise.

In particular, wastewater treatment technologies involve industry engineers and institutions associated to water treatment while irrigation involves agronomic engineers, farmers, and institutions associated to agriculture. It is common knowledge that water treatment and agriculture lack effective communication and even present signs of rivalry especially in Africa. The challenge in stakeholder involvement is therefore to identify and engage both worlds.

2.1 Rationale

The rationale to involve stakeholders in the reuse of treated wastewater for agriculture and in Integrated Water Resource Management (IWRM), is based on the Common Implementing Strategy, Guidance document No. 8, Public Participation in relation to the Water Framework Directive (CIS, 2003).

The fundamental rationale for Stakeholder Participation in the WFD is "to ensure the effective implementation and achievement of the environmental objectives of water management (good status in 2015). The main purpose of public participation is to improve decision-making, by ensuring that decisions are soundly based on shared knowledges, experiences and scientific evidence, that decisions are influenced by the views and experience of those affected by them […]" (CIS, 2003).

The benefits of stakeholder participation in wastewater reuse for irrigation are seen as:

- Increasing public awareness of environmental issues as well as the environmental situation related to waste water reuse at river basin district and local catchment;
- Making use of knowledge, experience and initiatives of the different stakeholders and thus improving the quality of plans, measures and river basin
- Sustainable management;
- Public acceptance, commitment and support regarding decision taking processes;
- More transparent and more creative decision making;

- Less litigation, misunderstandings, fewer delays and more effective implementation;
- Social learning and experience – if participation results in constructive dialogue with all relevant parties involved then the various publics, government and experts can learn from each other's "water awareness" (adapted from CIS, 2003).

Furthermore, stakeholder consultation is viewed as a way to "avoid potential conflicts, problems of management and costs in the long term" (Ibidem, 2003). This rationale for stakeholder consultation is not novel. The different reasons and benefits of stakeholder consultation serve as a basis for interpretation of the practical participative exercise.

2.2 Methodology

2.2.1 Identification of stakeholders

A common and practical distinction exists between primary and secondary stakeholders (Bryson 2004, Gilmour & Beilin 2007). The group of primary stakeholders comprises end-users of the project's outcome and those whose participation and support is required for the project to be able to succeed. They are parties that might not be directly connected to the project, but that are critical for its success. Secondary stakeholders are all the other stakeholders that are not directly involved in transactions regarding the project, but that do have the capacity to influence, or might be affected by, the project. In order to avoid confusion, a clarification is made in MADFORWATER by distinguishing:

- Consultation stakeholders (primary stakeholders): stakeholders involved in the SAB and therefore in the different SCWs. The consultation Stakeholders were identified with the support of all the consortium members. Thanks to the participants to the three initial consultation workshops, the list was validated and updated for the subsequent SCWs.
- Dissemination stakeholders (secondary stakeholders): stakeholders specifically targeted according to the dissemination and communication strategy to deliver key messages. The same methodology as for the previous case was used, including also a detailed web-based search. A specific search on the CORDIS database with relevant EU-funded projects was also developed. All MADFORWATER consortium members were asked to share contact details of existing networks specifically working on water management, waste water reuse and irrigation in North Africa and in Europe. Due to the large group of potential "dissemination stakeholders" identified, the institutions were grouped in broad categories:
    - Commercial companies
    - Academic and research institutes/universities
    - Local/National/EU public authorities, bodies or governments
    - Investors
    - (International) Associations & NGOs
    - Media organizations
    - Consulting.

2.2.2 Stakeholder database

A stakeholder data base was created based on the results of the above-mentioned process. The database, used only for internal purposes (confidential), was continuously updated along the whole project.

Although the initial categorization of the stakeholders was based on their characteristics, interests, attitude, influence and relevant knowledge, it was decided to use a more relevant and effective categorisation based on 4 criteria: sector of activity / competences, nature of stakeholder, preferred language for dissemination and communication, country. For each criterion, the following possible values were assigned:

- Sector of activity / competencies:
  - Agriculture
  - Waste water producers
  - Water resources management
  - Treated wastewater users
  - Environmental and social legal aspects
  - End-users & consumers
- Nature of stakeholder:
  - Commercial companies
  - Academic and research institutes/universities
  - Local/National/EU public authorities, bodies or governments
  - Investors
  - (International) Associations & NGOs
  - Media organizations
  - Consulting
- Preferred language for dissemination and communication:
  - Arabic
  - English
  - French

All personal data about stakeholders collected by Wageningen Environmental Research (WER) from questionnaires and during the Stakeholder Consultation Workshops are carefully protected in compliance with relevant national data protection legislation of the EU member states and with the Regulation (EU) 2016/679 (GDPR; http://data.europa.eu/eli/reg/2016/679/oj). WER provided information on the processing of personal data to the interviewees and obtained from them the consent to the processing of his or her personal data. Moreover, WER stores all materials that could lead to an identification of the data subjects separately from any other information and protects all the files containing confidential information and personal details. These files are accessible only to the members authorized by the research team that received preliminarily specific information and training on the procedures for data collection, storage and processing and they will be destroyed as soon as they are no longer necessary for the research, however they will not be kept for more than 4 years after the project end. The actual research data are stored in such a way not to allow the direct identification of the subject that provided them and adopting measures for anonymization. The results of questionnaires and interviews have been shared among project partners only as anonymous data; the research data resulting from analysis do not contain any personal data that may permit the identification of individual participants. Data and information collected have been and will be disseminated and published only in an aggregate and anonymous form.

2.3 Main results of the initial stakeholder mapping

Although the information resulted from the initial Stakeholder analysis, both for Consultation stakeholders and for Dissemination stakeholders is confidential, a short summary with the most relevant institutions identified is reported below.

2.3.1 Stakeholder analysis in the Nile Delta, Egypt

The initial stakeholder map for the Egyptian case study is presented in both Figure 1 and Table 1. The contact details and names of the people representing those institutions are not shown (confidential).

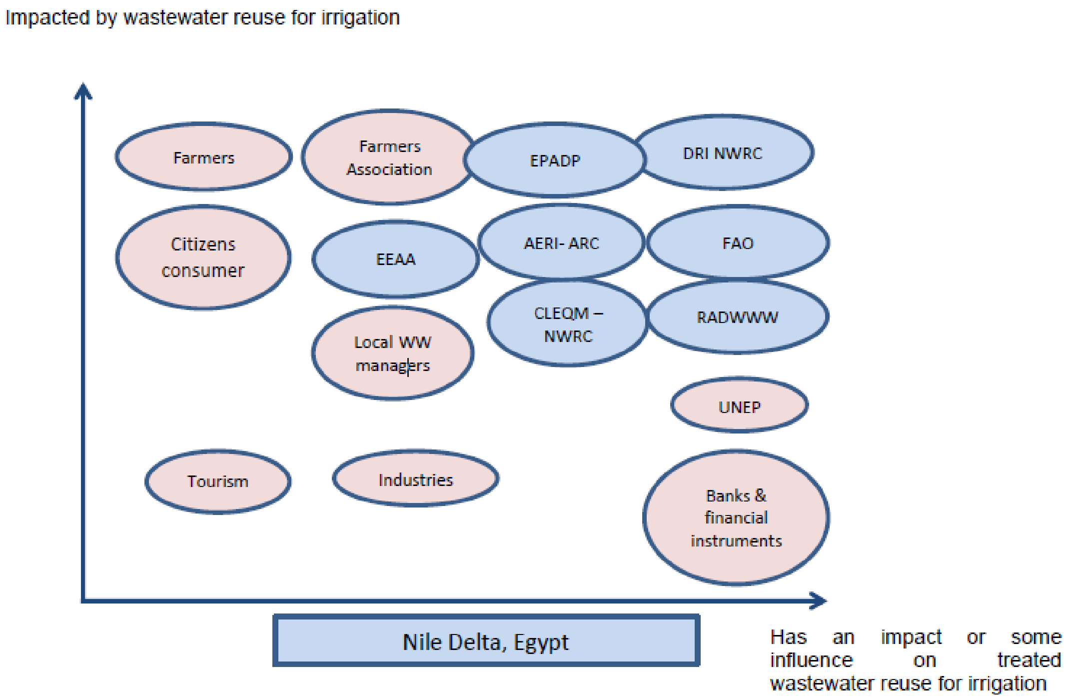


Figure 1. Initial stakeholder map, Nile Delta, Egypt. Blue ovals are stakeholders attending the initial SCW. In pink, stakeholders that should be included in the following SCWs.

Table 1. Explanation of the stakeholder acronyms used in Figure 1.

EDADP	Regulatory Authority for Drinking Water and Waste Water
DRI NWRC	Drainage Research Institute - National Water Research Centre
EEAA	Ministry of Environment and Egyptian Environmental Affairs
AERI-ARC	Agricultural Economics Research Institute - Agricultural Research Centre
CELQM-NWRC	Central Laboratory for Environmental Quality Monitoring - National Water Research Centre
RADWWW	Regulatory Authority for Drinking Water and Waste Water

2.3.2 Stakeholder analysis in Souss-Massa, Morocco

The initial stakeholder map for the Moroccan case study is presented both in Figure 2 and Table 2. The contact details and names of the people representing those institutions are not showed (confidential).

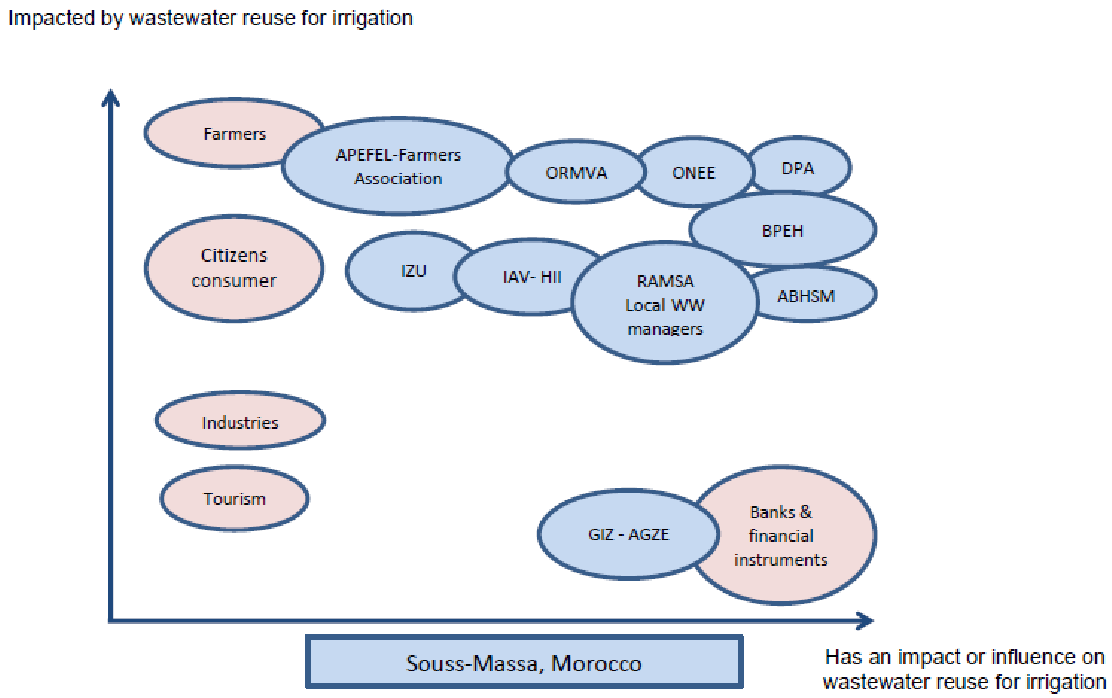


Figure 2. Initial stakeholder map, Morocco. Blue ovals are stakeholders attending the initial SCW. In pink, stakeholders that should be included in the following SCWs.

Table 2. Explanation of the stakeholder acronyms used in Figure 2.

ORMVASM	Office Régional de Mise en Valeur Agricole du Souss-Massa
ONEE	Office National de l'Électricité et de l'Eau
DPA - TIZNIT	Direction Provincial de l'Agriculture TIZNIT
BPEH	Bureau de la Planification et des Equilibres Hydrauliques,
IZU	ZOHR UNIVERSITY
IAV- HII	Institut Agronomique et Vétérinaire HASSAN II
ABHSMD	Agence du Bassin Hydraulique de Souss Massa et Dràa
RAMSA	Régie Autonome Multi-Services d'Agadir

2.3.3 Stakeholder analysis in Cap Bon - Miliane, Tunisia

The initial stakeholder map for the Tunisian case study is presented in both Figure 3 and Table 3. The contact details and names of the people representing those institutions are not showed (confidential).

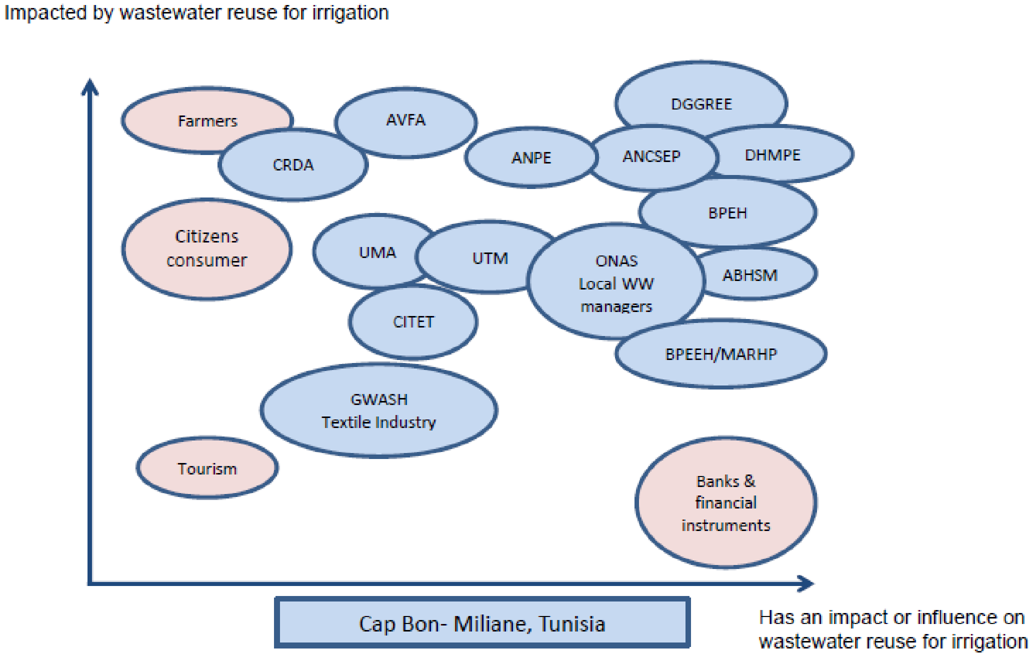


Figure 3. Initial Stakeholder map, Cap Bon - Miliane, Tunisia. Blue ovals are stakeholders attending the initial SCW. In pink, stakeholders that should be included in the following SCWs.

Table 3. Explanation of the stakeholder acronyms used in Figure 3.

CRDA	Commissariat Régional de Développement Agricole Nabeul
AVFA	Agence de Vulgarisation et de formation agricole
ANPE	Agence nationale pour la protection de l'Environnement
DGGREE	Direction Générale du Génie Rural et de l'Exploitation des Eaux – ministere de l'agriculture
ANCSEP	Agence Nationale de Contrôle Sanitaire de l'Environnement et des Produits
DHMPE	Direction de l'Hygiène du Milieu et Protection de l'Environnement
BPEH	Bureau de Planification des Equilibres Hydriques
UMA	Univeristé de Manouba - Institut Superieur de Biotechnology de Sidi Thabet
UTM	Université Tunis el Manar
ONAS	Office National d'Assainissement
GWASH	Global Washing-
BPEEH/MARHP	Ministere de l'Agriculture des Ressources Hydriques et de la Pèche

3 Initial SCWs: identification of factors affecting wastewater treatment and reuse for agriculture purposes:

As was stated in the introductory section, a total of 3 SCWs, one per target MAC country, were carried out during the first months of the project. Besides the aforementioned stakeholder mapping, the initial SCWs were used to identify the most relevant factors affecting wastewater treatment and reuse for agriculture purposes, including an identification of the key barriers. An assessment of the initial perception by the local partners of the technologies proposed by project was also carried out.

3.1 General framework for the analysis of drivers and barriers affecting the reuse of treated wastewater for agriculture in Egypt, Morocco and Tunisia

The general goal of the MADFORWATER project is to develop an integrated set of technological and management instruments for the enhancement of wastewater treatment, treated wastewater reuse for irrigation and water efficiency in agriculture, with the final aim to reduce water vulnerability in selected basins in Egypt, Morocco and Tunisia. All adaptation actions were characterized by a participatory approach, ensured by the involvement of relevant stakeholders.

A comprehensive questionnaire (indicated in the following as questionnaire A) was developed to support the stakeholder-based adaptation approach. The aim of the questionnaire, reported in Annex A, was to gather information on the level of water vulnerability in Egypt, Morocco and Tunisia, and in particular to identify the needs and gaps in terms of (1) development and adaptation to the local context of WW treatment, irrigation technologies and treated WW reuse in agriculture, and (2) development and implementation of strategies, economic instruments and policies in the field of water management. In other words, the aim was to investigate the factors that influence the development and application of technologies and management tools in the field of water management. Factors that prevent (negative influence) such development are called Barriers, and those that encourage it (positive influence) the reuse are called Drivers. The questionnaire, initially developed in English, was translated in French, in order to make it accessible to most stakeholders from Egypt, Morocco and Tunisia.

The questionnaire was focused on 3 themes (see full questionnaire in Annex A):

- Part A: Adaptation to the local context of WW technologies
- Part B: Adaptation to the local context of irrigation technologies
- Part C: Comprehensive evaluation of barriers and drivers in the field of water management, with specific focus on treated WW reuse.

The questionnaire was used as a tool to facilitate the discussion during the three Stakeholder Consultation Workshops (SCWs) that took place in Cairo (November 2016), Agadir (December 2016) and Tunisia (May 2017). Those initial SCWs were mainly focused in the identification and evaluation of barriers and drivers in the field of water management.

A short explanation of the initial consultation process and of the main outputs is reported in the following sections.

3.2 Initial Stakeholder Consultation Workshops

A first validation of the questionnaire was performed in October 2016, by sending it to 26 stakeholders and members of the SAB. Only 9 answers were received.

The main conclusion obtained from the feedback of the SAB members was that is much more effective to focus on certain topics than on the whole questionnaire since it is difficult to get experts both in WW treatment and Irrigation. The SAB members also agreed that the feedback from the questionnaire will be much more effective on a workshop than from distance, since the moderator could provide further details regarding the topics to be covered. This is also valid for the identification of barriers and drivers, since it would be easier to do it through a working group. According to this feedback, the questionnaire was slightly adapted and used in the planned initial SCWs.

As illustrated above, 3 SCWs, one per target MAC country, were carried out during the first months of the project. These SCWs were mainly focused on Part C of the questionnaire “Comprehensive evaluation of barriers and drivers in the field of water management, with specific focus on treated WW reuse”.

Section C of the questionnaire includes a list of factors that can represent drivers or barriers for the development of a sustainable water management (Annex A, section C). These factors are articulated into 5 categories. Having a critical view of the current situation in his/her country, each participant was asked to evaluate whether each factor represents a barrier or a driver and rate it according to the following criteria:

- if the factor is considered a barrier: B1= low barrier, B2= moderate barrier, B3 = major barrier
- if the factor is considered a driver: D1= low driver, D2= moderate driver, D3= major driver
- I don’t know= 0

The factors are inspired by the work of Stathatou et al. (2016), and reframed. However, the participants had the opportunity to define additional factors and to rate them.

3.3 Initial SCWs: specific consultation in Egypt

3.3.1 General description

Date: 17th of November 2016

Location: Cairo, Egypt.

Objectives: stakeholder mapping

In the Egyptian initial SCW, MADFORWATER researchers met 5 Egyptian stakeholders affiliated to the following public Egyptian institutions: Egyptian Public Authority for Drainage Projects – EPADP, Regulatory Authority for Drinking Water and Waste Water – RADWWW, Egyptian Environmental Affairs Agency EEEA, Agricultural Economics Research Institute - Agricultural Research Centre, AERI- ARC, Office for Irrigation Improvement – Ministry of Water Resource and Irrigation – OII- MWRI. Thus, the Egyptian stakeholders that participated to the meeting of November 2016 were representatives of (i) agricultural research institutions, (ii) public institutions for the management of drinking water, wastewater, drainage water and irrigation and (iii) environmental regulatory agencies.

In this SCW, the Egyptian stakeholders provided an overall introduction to water management in Egypt, but the limited time available did not allow to perform an in-depth analysis of drivers and barriers for a sustainable water management in Egypt. This is why the SCW was mainly focused in the development of the stakeholder mapping.

3.4 Initial SCWs: specific consultation in Morocco

3.4.1 General description

Date: 16 December 2016.

Location: Agence du Bassin Hydraulique du Souss Massa (ABHSMD), Agadir, Morocco.

Objectives: stakeholder mapping and adaptation approach of technologies and non-technological instruments (management, monitoring, training) to identify barriers and drivers to promote the reuse of treated waste water for irrigation.

A total of 17 stakeholders external to MADFORWATER, coming from Morocco and Tunisia, participated to this SWC. In addition, 24 MADFORWATER researchers participated to the Moroccan SWC. The Moroccan stakeholders were affiliated to the following institutions:Office National de l'Électricité et de l'Eau Potable – ONEE, Régie Autonome Multi-Services d'Agadir – RAMSA, Bureau de la Planification et des Equilibres Hydrauliques – BPEH, Agence du Bassin Hydraulique de Souss Massa et Dràa ABHSMD, Direction Provincial de l'Agriculture de TIZNIT – DPA, Office Régional de Mise en Valeur Agricole du Souss-Massa ORMVASM , Association Marocaine des Producteurs et Exportateurs de Fruits et Légumes – APEFEL, IBN ZOHR UNIVERSITY - IZU, German Corporation for International Cooperation - GIZ-AGIZE. Thus, the Moroccan stakeholders that participated to the meeting of December 2016 were representatives of wastewater management public companies, basin authorities, public institutions for agricultural management, farmers associations, research institutions and international cooperation organizations.

3.4.2 Main results

A summary of the main outputs of the Moroccan initial SCW can be found in Table 4. The additional factors defined by stakeholders during the workshop are highlighted in grey.

Table 4. Stakeholders' rating of factors impacting on sustainable water management in Morocco.

The additional factors defined by stakeholders during the workshop are highlighted in grey. B1= low barrier, B2= moderate barrier, B3 = major barrier, D1= low driver, D2= moderate driver, D3= major driver, 0 = I don't know.

Policy factors	**Rating : B3, B1, B1, 0, D1, D2, D3**
P1. National / regional policies on Water Resources Management (WRM)	**D3**
P2. National / regional environmental policies	
P3. Land use policies	
P4. Transnational or transboundary treaties & agreements	
P5. Trade policies (exports of agricultural products)	
P6. Agricultural policy	
P7. National Plan or regional plan to promote treated wastewater reuse (50 million de M3 per year)	**D3**

Economic factors	
E1. Availability of governmental & public funds	
E2. Indirect financial incentives	
E3. Freshwater pricing schemes for food-crop irrigation	
E4. Freshwater pricing schemes for non-food crop	**B3**
E5. Freshwater pricing schemes for industrials uses	
E6 Drinking water pricing schemes	
E6. Farm operating costs (pumping cost of surface GW)	
E8. Investment cost for agricultural irrigation technologies	**B3**

E9. Lack of financial resources to finance analysis (chemical and biologic) and tertiary treatment	**B3**

Social factors	
S1. Public awareness on water scarcity problems	**D3**
S2. Public awareness on treated wastewater reuse as a resource	**D3**
S3. Public perceptions on the consumption of crops irrigated with reclaimed water	**B3**
S4. Involvement of different stakeholder groups in decision-making processes	
Pas de reticence à l'utilisation mais au paiement	B3

Technical factors	
T1. Technical expertise & know-how on wastewater (WW) treatment & supply	
T1.1 For the irrigation of food crops	
T1.2 For the irrigation of non-food crops	
T1.3 For unrestricted urban uses	
T1.4 For restricted urban uses	
T1.5 For industrial processes	
T2. Technical expertise & know-how on using reclaimed water	
T2.1 For farmers and field workers	
T2.2 For industries	
T2.3 For urban citizens	
T3. Irrigation systems used	
Analysis of TWW focused on BOD, COD TSS, but should focus on Total N and Total P	**B1**
High salinity of TWW	**B1**
Distance agricultural land to Wastwater treatment works	**B3**
Lack of monitoring of TWW quality	**B3**

Legal & institutional factors	
L1. Ownership of treated WW – Water rights law	**B3**
L2. Regulatory framework on treated wastewater reuse	**B3**
L3. Enforcement of regulations and laws	**B3**
L4. Delineation of responsibilities among the institutions involved in water & WW management	**B3**
L5. Communication between ministries	**D3**
L6. communication between decision makers and end-users	**0**
L7. Capacities of decision makers to change laws and practices	
No Institution in charge of Treated Water reuse management	**B3**
Lack of official guidance text to clarify the roles of institution towards end-users	**B3**
Lack of involvement of institution from public health	**B3**
Lack of clear role and political will	**B3**
Who should monitor TW quality analysis ? ONEE ?	**B3**
What is the finance mechanism for the tertiary treatment	**B3**
ONEE protection de l'environnement pas de l'agriculture	**B3**
Need a new interministeriel overarching body	**B3**

In conclusion, the main barriers for a sustainable water management in Morocco, with a specific focus on treated WW reuse, resulted to be the following ones:

- Lack of coordination and communication between the institutions involved in waste water treatment: one solution could be a regional contract for the reutilization on the model of "water table contract"
- Not clear responsibilities: who is going to take the responsibility for the reutilization?
- Lack of roles definition, who does what?

- Financial constraints: who is going to pay for the analysis and the use by the third parties: is the Health Department? Are the end users? Is the Agriculture Department?
- Lack of funds to finance tertiary treatment, to monitor treated WW, supply treated WW to irrigation land.
- Lack of clear legislation: which treated wastewater quality for with type of irrigation for which type of agro-product?
- Acceptance: who is going to control the quality of agriculture products irrigated with treated waste water?
- A transdisciplinary institution with a new mandate focused on treated WW reuse in agriculture, is needed to overcome the fragmentation of responsibility and coordinated all existing institutions.
- The lack of support, resources, political will, administrative hurdles, lack of cooperation between existing agencies that manage the water resources, wastewater, ground water, water supply, agriculture prevent from an integrated wastewater reuse strategy.

The alternative uses of treated wastewater in Morocco resulted to be the following ones:

- Recharge of groundwater and protection of wetland
- Irrigation of non-food crops like golf courses. However, the golf courses pump ground water resources freely and are not willing to change irrigation practices.
- Golf course manager are worried that salinity content impact on the quality of grass. The questions are who is responsible for the quality of treated WW and who is responsible for the irrigation practices.

3.5 Initial SCWs: specific consultation in Tunisia

3.5.1 General description

Date: 16th of May 2017

Location: Cap Bon - Miliane, Tunisia.

Objectives: stakeholder mapping and adaptation approach of technologies and non-technological instrument (management, monitoring, training) to identify barriers and drivers to promote the reuse of treated waste water for irrigation.

A total of 28 Tunisian stakeholders external to MADFORWATER participated to this SWC. In addition, 5 MADFORWATER researchers participated to the Tunisian initial SWC. The Tunisian stakeholders affiliated to the following institutions and companies: Office National d'Assainissement – ONAS, Bureau de Planification des Equilibres Hydriques – BPEH, Commissariat Régional de Développement Agricole Nabeul – CRDA, Direction Générale du Génie Rural et de l'Exploitation des Eaux – Ministère de l'agriculture – DGGREE, Ministère de l'Agriculture des Ressources Hydriques et de la Pèche BPEEH, Agence de vulgarisation et de formation agricole – AVFA, Agence nationale pour la protection de l'Environnement – ANPE, Centre International des Technologies de l'Environnement – CITET, Agence Nationale de Contrôle Sanitaire de l'Environnement et des Produits – ANCSEP, Direction de l'Hygiène du Milieu et Protection de l'Environnement – DHMPE, Institut National de la Météorologie – INM, Direction Générale de l'Environnement et de la Qualité de la Vie DGEQV, Global Washing-

GWASH. Thus, the Tunisian stakeholders that participated to the meeting of May 2017 were representatives of wastewater management public companies, public institutions for agricultural management, research institutions, environmental protection agencies, institutions for the monitoring of climate and climate change and WW producing companies (textile sector).

3.5.1 Main results

A summary of the main outputs of the Tunisian initial SCW can be found in Table 4. The additional factors defined by stakeholders during the workshop are highlighted in grey.

Table 5. Stakeholders' rating of factors impacting on sustainable water management in Tunisia.

The additional factors defined by stakeholders during the workshop are highlighted in grey. B1= low barrier, B2= moderate barrier, B3 = major barrier, D1= low driver, D2= moderate driver, D3= major driver, 0 = I don't know.

Policy factors	**Rating : B3, B1, B1, 0, D1, D2, D3**
P1. National / regional policies on Water Resources Management (WRM)	**D3**
P2. National / regional environmental policies	
P3. Land use policies	
P4. Transnational or transboundary treaties & agreements	
P5. Trade policies (exports of agricultural products)	
P6. Agricultural policy	
P7. National Plan or regional plan to promote treated wastewater reuse (50 million de M3 per year)	**D3**

Economic factors	
E1. Availability of governmental & public funds	
E2. Indirect financial incentives	
E3. Freshwater pricing schemes for food-crop irrigation	
E4. Freshwater pricing schemes for non-food crop	**B3**
E5. Freshwater pricing schemes for industrials uses	
E6 Drinking water pricing schemes	
E6. Farm operating costs (pumping cost of surface GW)	
E8. Investment cost for agricultural irrigation technologies	**B3**
E9. Lack of financial resources to finance analysis (chemical and biologic) and tertiary treatment	**B3**

Social factors	
S1. Public awareness on water scarcity problems	**D3**
S2. Public awareness on treated wastewater reuse as a resource	**D3**
S3. Public perceptions on the consumption of crops irrigated with reclaimed water	**B3**
S4. Involvement of different stakeholder groups in decision-making processes	
Pas de reticence à l'utilisation mais au paiement	B3

Technical factors	
T1. Technical expertise & know-how on wastewater (WW) treatment & supply	
T1.1 For the irrigation of food crops	
T1.2 For the irrigation of non-food crops	
T1.3 For unrestricted urban uses	
T1.4 For restricted urban uses	
T1.5 For industrial processes	
T2. Technical expertise & know-how on using reclaimed water	
T2.1 For farmers and field workers	
T2.2 For industries	
T2.3 For urban citizens	
T3. Irrigation systems used	

Analysis of TWW focused on BOD, COD TSS, but should focus on Total N and Total P	**B1**
High salinity of TWW	**B1**
Distance agricultural land to Wastwater treatment works	**B3**
Lack of monitoring of TWW quality	**B3**

Legal & institutional factors	
L1. Ownership of treated WW – Water rights law	**B3**
L2. Regulatory framework on treated wastewater reuse	**B3**
L3. Enforcement of regulations and laws	**B3**
L4. Delineation of responsibilities among the institutions involved in water & WW management	**B3**
L5. Communication between ministries	**D3**
L6. communication between decision makers and end-users	**0**
L7. Capacities of decision makers to change laws and practices	
No Institution in charge of Treated Water reuse management	**B3**
Lack of official guidance text to clarify the roles of institution towards end-users	**B3**
Lack of involvement of institution from public health	**B3**
Lack of clear role and political will	**B3**
Who should monitor TW quality analysis ? ONEE ?	**B3**
What is the finance mechanism for the tertiary treatment	**B3**
ONEE protection de l'environnement pas de l'agriculture	**B3**
Need a new interministeriel overarching body	**B3**

In conclusion, the main barriers for a sustainable water management in Tunisia, with a specific focus on treated WW reuse, resulted to be the following ones:

Legal & institutional factors:

- The biggest barrier is the lack of political will to define clear responsibilities between the wastewater agencies, the farmers union, the lack of dialogue from national, regional and local level across all type of institution: water resource management, wastewater treatment and environmental management, agriculture and public health.

Economic factors:

- The lack of available funds to have suitable treatment, to supply the treated WW to farmland are major barriers. Although water is paid in most case it is still highly subsidised and the price of water especially in agriculture is far from its actual cost. This price distortion is a barrier to promote treated WW.

Technical factors:

- T1. Technical expertise & know-how on WW treatment & supply: expertise's are available in Tunisia but the centralisation of decision making and of institution disconnect expert form local reality, poor management of local knowledge is a strong barrier to Reuse.
- T2. Technical expertise & know-how on using reclaimed water: continuous training is necessary to reinforce communication, programme monitoring. Round table or trans sectorial committee are necessary: waste water manager – farmers.
- T3: Stakeholder highlighted a lack of irrigation system adapted to treated WW. MADFORWATER is expected to bridge this technological gap and to offer solutions.

Social factors:

- The public acceptance is a moderate barrier but thanks to awareness campaign of the population farmers, end-user to water scarcity, it is expected to become a driver.

The alternative uses of treated wastewater in Tunisia resulted to be the following ones:

- Ground water recharge and irrigation for non-crop usage (golf courses, mainly).

3.6 Selection of the most critical barriers to be addressed

Based on the results from the initial SCWs, especially the ones developed in Tunisia and Morocco, a further analysis of the results was developed to identify and select the key barriers to be tackled to the reuse of treated wastewater for irrigation. In particular, the average of the scores assigned by stakeholders to each factor was calculated. The resulted are presented in Figures 4-8. Drivers are represented in green. Barriers are presented in yellow, orange and red according to their perceived importance.

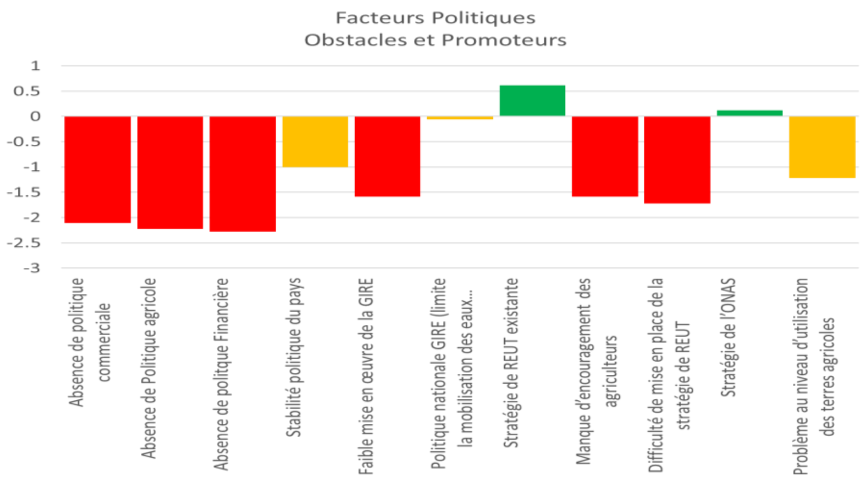


Figure 4. Stakeholders' rating of factors impacting on sustainable water management in MAC countries: policy factors, average values.

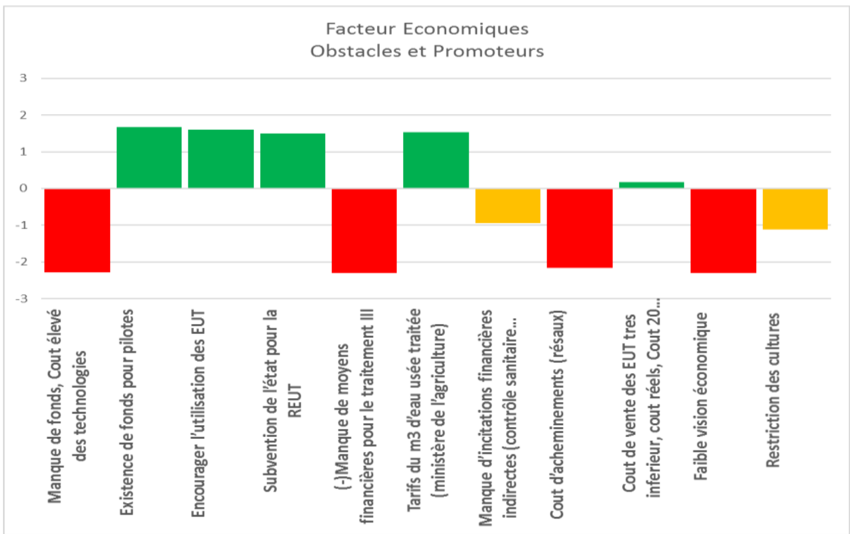


Figure 5. Stakeholders' rating of factors impacting on sustainable water management in MAC countries: economic factors, average values.

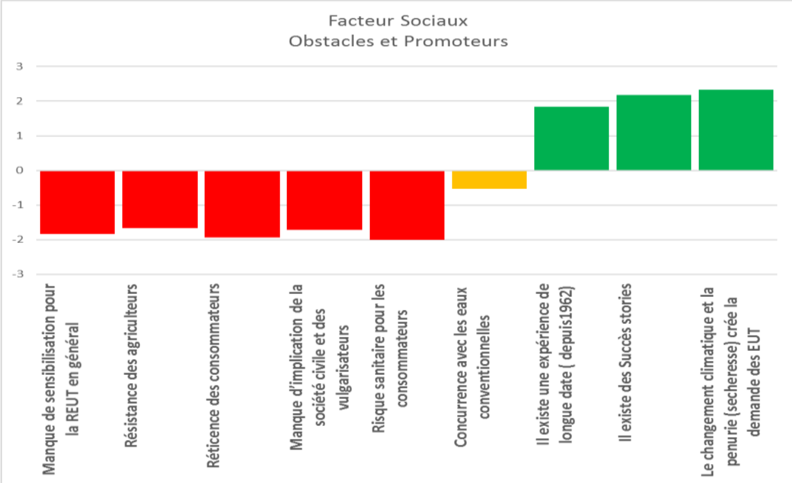


Figure 6. Stakeholders' rating of factors impacting on sustainable water management in MAC countries: social factors, average values.

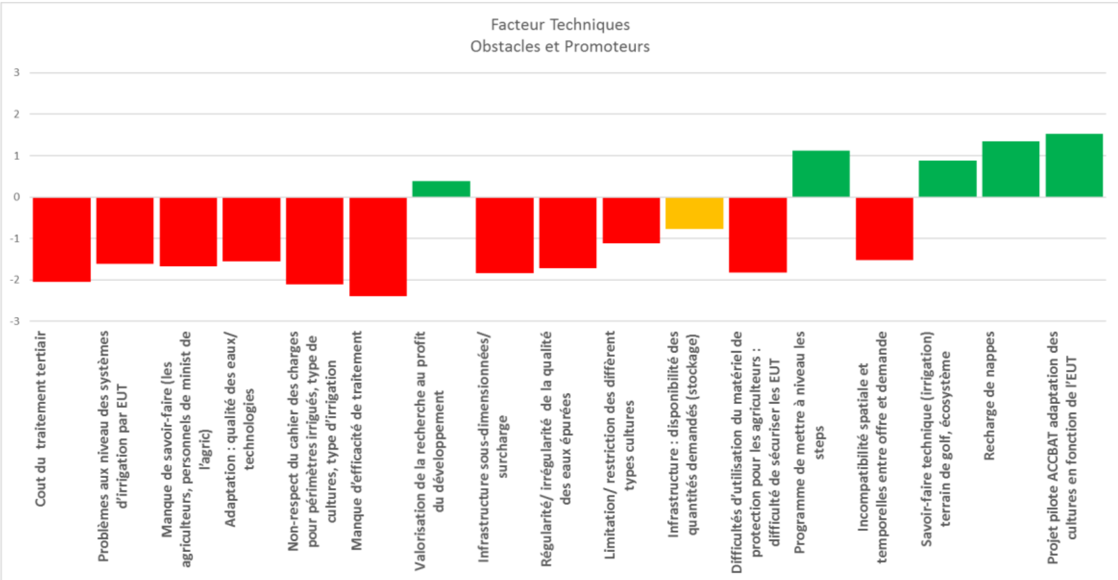


Figure 7. Stakeholders' rating of factors impacting on sustainable water management in MAC countries: technical factors, average values.

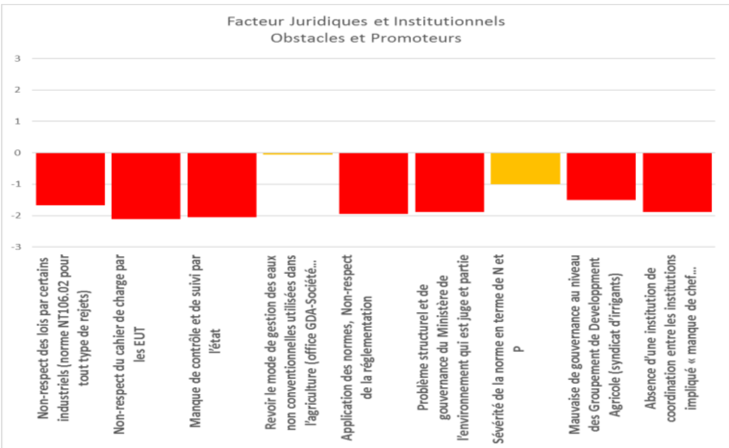


Figure 8. Stakeholders' rating of factors impacting on sustainable water management in MAC countries: legal and institutional factors, average values.

By comparing the average score assigned to each factor, only those perceived as a major barrier were selected. In total, the 22 barriers reported in Table 6 were identified.

Table 6. Major barriers to sustainable water management in MAC countries.

Class of Factors	Selected Barriers	Average score
Policy Factors	P1 - Absence of commercial policy	-2.11
	P2 - Absence of Agricultural Policy	-2.22
	P3 - Absence of Financial Policy	-2.28
	P4 - Weak implementation of IWRM	-1.59
Economic Factors	E1 - Lack of funds, high cost of technologies	-2.28
	E2 - (-) Lack of financial resources for treatment III	-2.29
	E3 - Lack of indirect financial incentives (free health check for farmers)	-0.94
	E4 - Routing cost	-2.17
Social Factors	S1 - Lack of awareness for REUT in general	-1.83
	S2 - Resistance of farmers	-1.67
	S3 - Reluctance of consumers	-1.94
	S5 - Health risk for consumers	-2.00
Technical Factors	T1 - Problems with irrigation systems by EUT	-1.61
	T2 - Lack of know-how (farmers, agricultural ministry staff)	-1.67
	T3 - Lack of processing efficiency / undersized infrastructure / overload	-2.39
	T4 - Limitation / restriction of different types of crops	-1.11
Legal & Institutional Factors	I1 - Absence of an institution of coordination between the institutions involved "lack of conductor"	-1.89
	I2 - Non-compliance with specifications by EUTs, Application of standards, Non-compliance with regulations	-2.11
	I3 - Lack of control and monitoring by the state	-2.06
	I4 - Structural and governance problem of the Ministry of the Environment who is judge and party	-1.89
	I5 - Bad governance at the level of the Agricultural Development Group (Irrigators' Union)	-1.50

A relative comparison between the different barriers was developed, in order to understand better the potential effect of those barriers and to answer the following questions:

- Which barriers have a strong impact on other and a leverage effect?
- Which barriers are strongly influenced by others?

Following the methodology of Stathatou et al., (2016), the selected barriers were organised in a square matrix (22x22) and impact factors (0,1,2,3) were given to each pair of barriers. Factors were summed up and each barrier was then characterised by 2 indexes:

- Index X, representing how barrier "i" is influenced by the other barriers; it is also called the passive sum;
- Index Y, representing the overall influence (or impact) of barrier "i" on the other barriers; this index is also called the active sum;

Each barrier was then plotted in Figure 9 according to these 2 indexes. This analysis enables to characterise the barriers into 3 categories:

- **Actives barriers**: they have a strong impact on other barriers, but they are poorly influenced by other barriers (high Y, small X; leverage effect).
- **Critical Barriers** : they are both influencing other barriers and influenced by other barriers. They are the most critical and complex barriers to address.
- **Reactive barriers**: weak impact, strongly influenced by other barriers (high X, small Y). These barriers are « followers », they will be tackled when active barriers become promoters. Strategies do not need to focus on them initially.

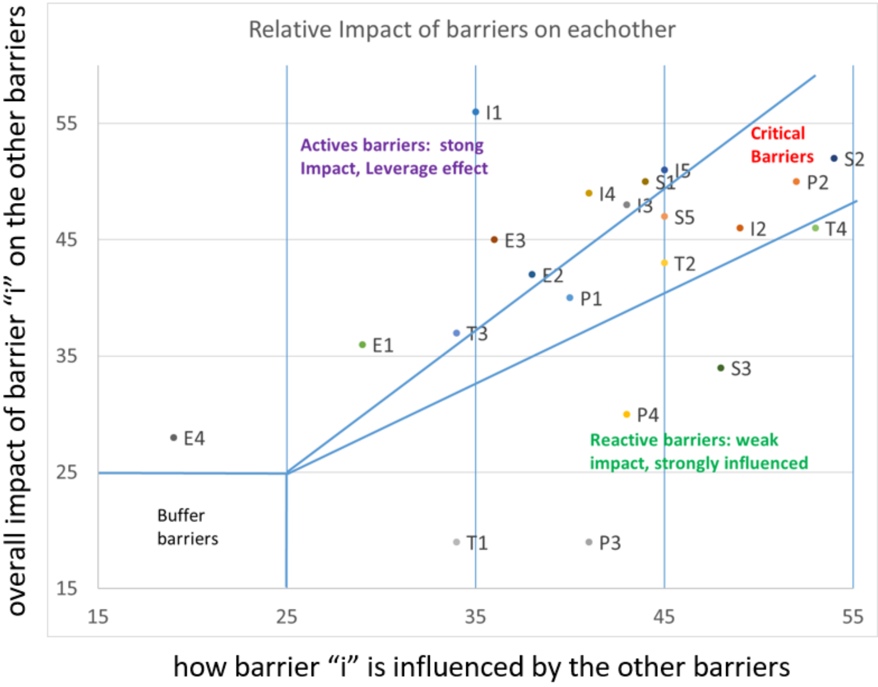


Figure 9. Relative impact of barriers

As a result of this 2 stage selection of barriers, the strategic factors on which strategies to enhance treated WW reuse should focus are the following (active and critical barriers):

- E2 - Lack of financial resources for tertiary WW treatment
- E3 - Lack of indirect financial incentives
- I1 - Absence of an institution of coordination between the different institutions involved
- I2 - Non-compliance of the effluents of WW treatment plants with regulations
- I4 - Structural and governance problem of the Ministry of the Environment, who is both judge and party
- I5 - Poor governance at the level of irrigators' / farmers' associations
- P2 - Absence of agricultural policy
- S1 - Lack of awareness on the advantages of WW reuse in general
- S2 - Resistance of farmers
- T3 - Lack of wastewater processing efficiency / undersized wastewater treatment infrastructure

Based in these results and as an outcome from the discussion with the working groups carried out during the SCWs that took place in Tunisia and Morocco, 5 barriers were identified as the most important ones that should be addressed in order to develop a more sustainable water management in MAC countries and specially to enhance WW reuse: E3 - Lack of financial incentives (economic factor); I1 - Absence of an institution of coordination between the different institutions involved (institutional factor); I5 - Poor governance at the level of irrigators' / farmers' associations (institutional factor); S1 - Lack of awareness on the advantages of WW reuse in general (social factor) and T3 - Lack of wastewater processing efficiency / undersized wastewater treatment infrastructure (technological factor).

The plan was to bring those barrier to the mid-term SCW in order to define future strategies to cope with them.

3.7 Initial perception of effectiveness and suitability to the local context of the MADFORWATER wastewater treatment and irrigation technologies

Although the initial SCWs were mainly focused in the identification of the key barriers to an effective reuse of treated WW, an initial assessment of the perception of effectiveness and suitability of the MADFORWATER technologies was developed, as well. The stakeholders were asked to answer, for each MADFORWATER technology, these two questions:

- is the technology perceived as effective?
- is the technology perceived as suitable, in relation to the specific context of your country?

The answers are reported in Table 7. The first answer refers to the effectiveness of the technology, the second refers to the suitability of the technology in relation to the local context. DK stands for “I do not know”.

Table 7. Initial stakeholder perception relatively to the wastewater treatment technologies developed by MADFORWATER.

For each technology and country, the first word indicates if the technology is effective in relation to the targeted WW type, whereas the 2nd word indicates if the technology is suitable in relation to the specific context of the country considered. DK = I do not know.

Techn. ID	Short description	Targeted WW type	Egypt	Morocco	Tunisia
1	Canalized lagoon with nitrification/denitrification and disinfection capacity	Municipal WW Drainage canal water	NO/NO	DK/YES	NO/YES
2	Nitrifying trickling filters filled with innovative high specific-surface carriers	Municipal WW	YES/YES	YES/YES	YES/YES
3	Constructed wetlands with plant growth promoting bacteria for tertiary treatment (N, P, emerging pollutants, heavy metals)	Municipal WW	YES/YES	DK/DK	YES/YES
4	Enzymatic degradation of fungicides, dyes and emerging pollutants with immobilized laccases	Municipal WW Fruit packaging WW Textile WW	DK/DK	DK/DK	YES/DK
5	Catalytic disinfection beds activated by solar UV light	Municipal WW	NO/NO	YES/YES	NO/NO
6	Flotation/flocculation integrated process	Fruit packaging WW	NO/DK	NO/YES	DK/DK
7	Membrane filtration + phenolic compounds adsorption with selective resins + anaerobic digestion in biofilm reactor	Olive mill WW	NO/DK	DK/DK	YES/NO
8	Aerobic sequenced batch reactor with lime addition	Olive mill WW	NO/NO	DK/DK	YES/NO

9	Granulated sludge bioreactor	Textile WW	DK/DK	DK/DK	NO/NO
10	Moving Bed Biological Reactor	Textile WW Fruit packaging WW	DK/DK	DK/DK	NO/NO
11	Dyes adsorption with innovative resins	Textile WW	DK/DK	DK/DK	NO/NO

Nitrifying filters and constructed wetlands to treat municipal WW were identified by the participants as the most effective/suitable solutions.

Although the moderator presented the main features of each technology before the questionnaire, some of the stakeholders felt that they did not have sufficient background information in order to answer to the questionnaire. This is the reason why several technologies were rated as DK or as Not effective/Not suitable. However, this initial perception was very valuable to show that MADFORWATER should put large efforts to demonstrate the suitability of these technologies trough the subsequent laboratory and field development of the technologies.

Table 8. Initial stakeholder perception relatively to the irrigation technologies developed by MADFORWATER.

For each technology and country, the first word indicates if the technology is effective in relation to the targeted WW type, whereas the 2nd word indicates if the technology is suitable in relation to the specific context of the country considered. DK = I do not know.

Techn. ID	Short description	Egypt	Morocco	Tunisia
A	Increased crop resistance to water scarcity and salinity through the addition of plant growth promotion bacteria to the irrigation water	NO/NO	DK/DK	YES/DK
B	Large spectrum soil moisture sensor calibrated for saline water	YES/NO	YES/YES	DK/YES
C	Low-pressure micro-sprinklers adapted to dry climates and to treated WW	YES/YES	NO/DK	YES/YES
D	Low-pressure calibrated nozzle adapted to dry climates and to treated WW	YES/YES	DK/DK	YES/YES
E	Re-engineered surface irrigation systems based on calibrated gated pipes	YES/YES	DK/DK	YES/YES
F	Open source software tool to determine the optimal irrigation amount and schedule	DK/NO	YES/YES	YES/YES

In case of the irrigation technologies, since stakeholders were already used to some of the technologies proposed, the initial perception of the participants was more positive. In this way, the use of soil sensors calibrated to saline water, the use or micro-sprinklers adapted to treated WW, the use of calibrated nozzle and gated pipes were valued as effective and suitable by most participants.

However, according to the participants, the project still needed to do a relevant effort to demonstrate the suitability of those technologies to be used with treated WW in MACs countries.

3.8 Evaluation of the Initial SCWs by the participants

The stakeholders who participated in the initial SCWs were asked to perform a final evaluation of the workshops, based on 20 criteria. As can be observed in Figure 10, the feedback was generally positive.

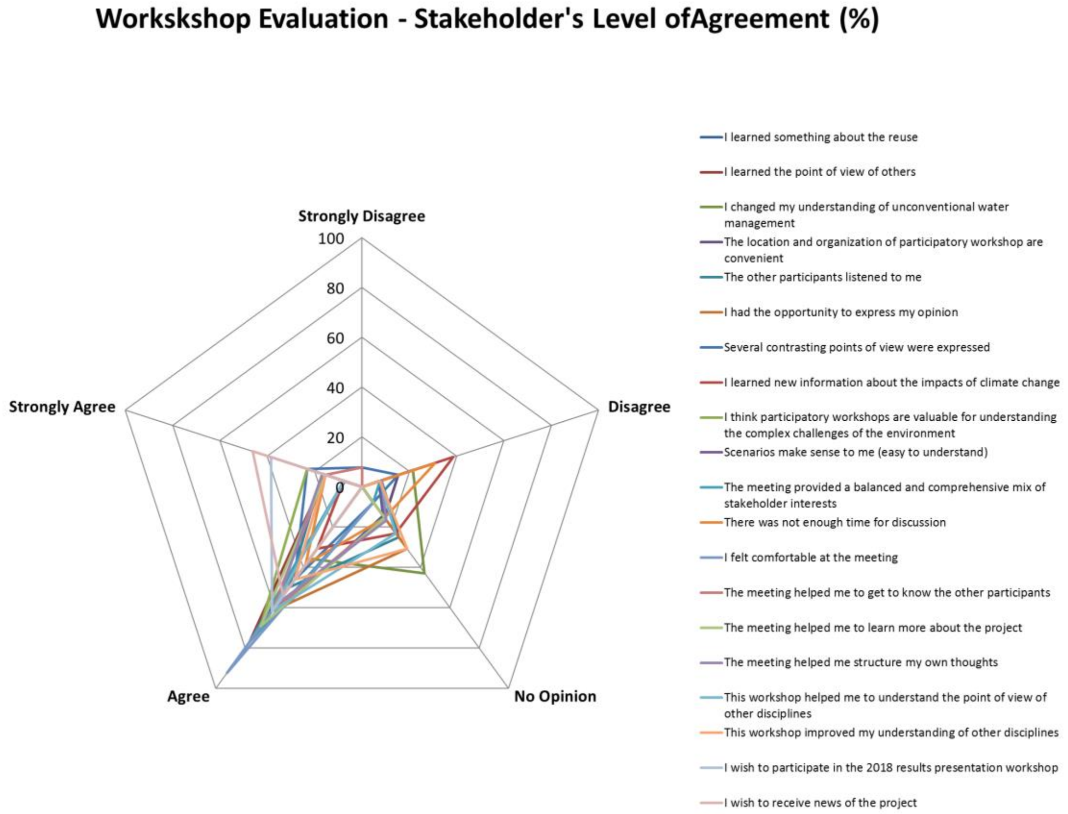


Figure 10. Stakeholders' evaluation of the 3 initial SCWs.

4 Suitability of technologies from the stakeholder perspective: the midterm SCW

4.1 General description of the mid-term SCW

Date: 8th and 9th of May 2018

Location: Cap Bon - Miliane, Tunisia.

Objectives:

- In deep evaluation of the effectiveness and suitability of the MADFORWATER WW treatment technologies
- In deep evaluation of the effectiveness and suitability of the MADFORWATER irrigation technologies
- Understand how to address the key barriers identified thanks to the initial SCWs.

24 Tunisian stakeholders met with MADFORWATER researchers at the City of Science, in Tunis. The stakeholders that participated to this meeting were affiliated to the following institutions: Agence Nationale de Protection de l'Environnement (ANPE), Direction Generale de l'environnement et de la qualité de la vie, Ministère des affaires locales et de l'environnement, Agence Nationale de Contrôle Sanitaire et Environnemental des Produits (ANCSEP), Ministry of Health, Observatoire national de l'agriculture (ONAGRI), Ministère de l'Agriculture, des ressources hydrauliques et de la pêche, Agence de la vulgarisation et de la formation agricoles (AVFA), Comité National d'Evaluation des Activités de Recherche Scientifique (CNEARS), Ministry of Higher Education and Scientific Research, Institut national de la météorologie, Centre de

Recherches et des Technologies des Eaux (CERTE), G-WASH, Groupement Interprofessionnel des Légumes (GIL). The Tunisian stakeholders that participated to the meeting of May 2018 were thus representatives of public institutions for agricultural management, water management institutions, research institutions, environmental protection agencies and ministries, institutions for the monitoring of climate and climate change, public institutions for training in the agricultural sector, farmers' associations and WW producing companies (textile sector).

During this meeting, stakeholders were asked to fill-in a questionnaire on each MADFORWATER technology, reported in Appendix B and C, in order to evaluate the level of suitability in relation to the social, technical, cultural and legislative context of Tunisia. The questionnaire was translated in French, in order to maximize the level of comprehension by the Tunisian stakeholders. The results of this questionnaire were taken into account for the selection of the technologies to be scaled up in the MADFORWATER field pilots.

4.1.1 Evaluation of WW treatment technologies

For each of the 9 selected WW treatment technologies, the level of suitability in relation to the local context was evaluated according to 6 criteria. For each evaluation criteria, stakeholders had the following choices: Not suitable at all; Poorly suitable; Reasonably suitable; Highly suitable; I do not know; Not applicable to this technology. The criteria used were:

- B1 - Is this technology suitable for your country / governorate / basin in terms of type of skills required for operation and maintenance?
- B2 - Is this technology suitable for your country / governorate / basin in terms of costs for operation and maintenance?
- B3 - Is this technology suitable for your country / governorate / basin in terms of availability of required reagents and spare parts?
- B4 - Is this technology suitable for your country / governorate / basin from a safety point of view?
- B5 - Is this technology suitable for your country / governorate / basin from a cultural point of view? In other words, do you think that this technology can be culturally accepted by the local population?
- B6 - Is this technology suitable for your country / governorate / basin from a legal point of view? Are there any legal constraints that could hinder the actual implementation of this technology?

4.1.2 Evaluation of irrigation technologies

For each of the 4 selected irrigation technologies, the level of suitability in relation to the local context was evaluated according to 4 criteria. For each evaluation criterion, stakeholders had the following choices: Not suitable at all; Poorly suitable; Reasonably suitable; Highly suitable; I do not know; Not applicable to this technology. The criteria used were:

- Is this technology suitable for your country / governorate / basin in terms of type of required farmer skills and easiness of operation and maintenance?
- Is this technology suitable for your country / governorate / basin in terms of pumping energy consumption regarding traditional techniques?
- Is this technology suitable for your country / governorate / basin from a cultural point of view? In other words, do you think that this technology can be easily accepted by the local population?
- Is this technology suitable for your country / governorate / basin from a safety point of view, in particular in relation to its use with treated wastewater?

4.2 Main results of technology evaluation

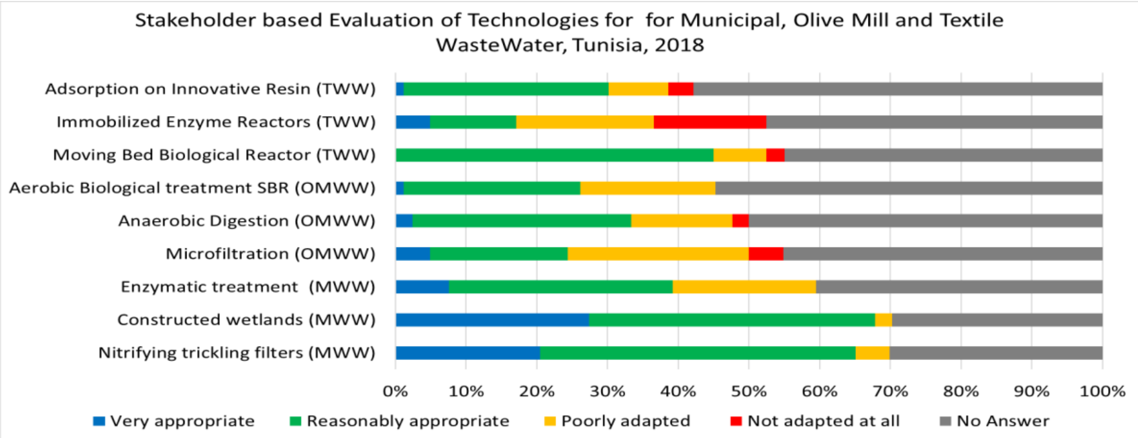
The results of the questionnaires are summarized in Figures 11 and 12. According to this analysis, the most suitable technologies for the treatment of the wastewaters targeted by MADFORWATER are:

- for textile wastewater: "Moving Bed Biological reactor" followed by "Adsorption on Innovative Resins"
- for olive mill wastewater: "Anaerobic digestion" followed by "Aerobic treatment in Sequenced Batch Reactor"
- for municipal wastewater: "Constructed wetlands" followed by "Nitrifying trickling filters".

As for the irrigation technologies, the most suitable ones result to be the innovative micro-sprinkler and the modelling tool for optimal irrigation scheduling with treated WW.

If the results are compared with those obtained during the initial assessment (section 3.7), the perception of the stakeholders reveal an increase in the acceptance level for most of the technologies.

The results of this stakeholder analysis contributed to the identification of the technologies to be scaled up in the 4 MADFORWATER pilot plants, as described in detail in Deliverable 4.1.



*Treated waste water (TWW); Olive mill and Textile waste water (OMWW); Municipal waste water (MWW)

Figure 11. Stakeholder evaluation of the MADFORWATER technologies for treating wastewater from Municipal (MWW), Olive Mill (OMWW) and Textile (TWW) origin.

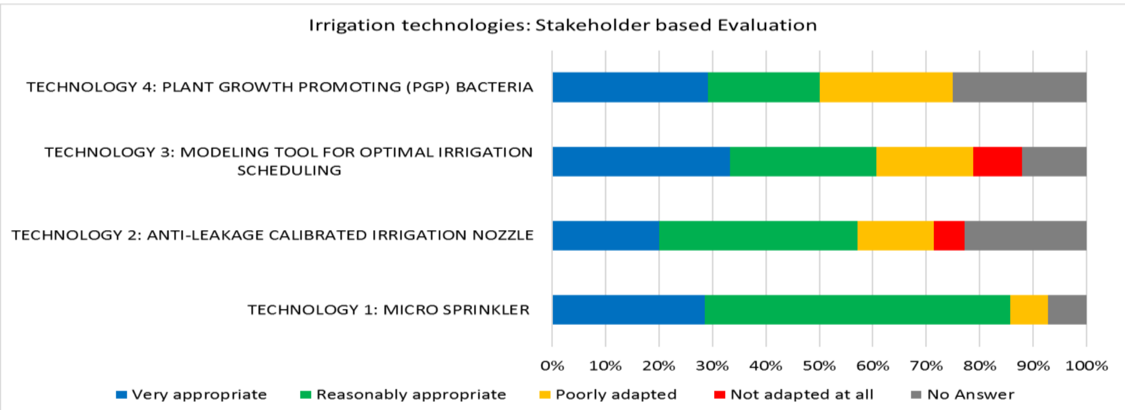


Figure 4. Stakeholder evaluation of the MADFORWATER technologies for irrigation with treated wastewater.

4.3 Development of strategies to address the key barriers previously identified

Following the definition of barriers and promotors developed during the initial SCWs (section 3.6), the most severe barriers to a sustainable water management with specific focus on the reuse of treated WW were selected to engage – in the framework of the mid-term SCW – a participative discussion aimed at identifying strategies to address these barriers. For doing this, the stakeholders were divided in 5 groups (one per key barrier) and asked to define a strategy according to the following analytical framework:

- Objectives of the strategy
- Actions

Since most of the participants of the mid-term SCW were from Tunisia, the discussion was mainly focused on this country. However, most of the results could be extrapolated (after adaptation) to the other countries. The main results are presented in the following tables.

Table 9. Strategies to address barrier I1 - Absence of an institution for coordination between the institutions involved in the reuse of treated WW.

Main Objective	Actions
Creation of a national commission on the reuse of treated WW	**A1: Composition of the commission** - Ministry of the Environment (National Office of sanitation ONAS, ANPE, International Center for Environmental Technologies in Tunisia CITET, municipality, ..) - Ministry of Agriculture (Directorate General of Rural Engineering and Water Exploitation DGGREE, Directorate General of Fisheries and Aquaculture DGPA, Directorate General of Water Resources DGRE, the Agency of the extension and the agricultural training AVFA, Regional Commissariat for Agricultural Development CRDA, agricultural development groups GDA, ..) - Ministry of Health (National Agency for Sanitary and Environmental Control of ANCSEP Products) - Private Sector (Golf Course Managers)
	A2: Mission and distribution of tasks Distribution of tasks - Ministry of the Environment → WW treatment and quality monitoring of treated WW - Ministry of Agriculture → good reuse practices, soil monitoring, crops and tablecloths - Ministry of Health → monitoring the quality of products - Private sector → investment and partnership Mission - to develop a national strategy for treated WW reuse by the National Commission - to develop an action plan by the regional commission
	A3: Organization at national and regional level - National Commission (State Secretariat of the Ministry of the Environment) - Regional Commission (governorate)
	A4 : Frequency of meetings - National Commission (twice a year) - Regional Commission (6 times a year)

Table 10. Strategies to address barrier I5 - Poor governance at the level of the Agricultural Development Group (Irrigators' Union).

Main Objective	Secondary Objectives	Actions
Good Governance of Water Resources Management at the GDA (Groupement des Développements Agricoles, Irrigators' Union)	Change the selection criteria for GDA (Groupement des Développements Agricoles) leaders	**A1.1:** Transparent elections of the head of the GDA
	Select specialized technical managers (in hydraulics, mechanics, irrigation)	**A2.1 :** Call for applications on CV / Diploma / Motivation
	Strengthen coordination between GDA (Irrigators' Union), CRDA (Regional Commissariat for Agricultural Development) -DGRE (Directorate General of Water Resources) - GR (Rural Engineering)	**A3.1:** Technical guidance of GDA
		A3.2: Collective work between the various stakeholders
	Control and monitoring of irrigated perimeters	**A4.1 :** Introducing Penalties for Offenders
	Awareness raising and dissemination of good water management	**A5.1** Maintenance and renovation of irrigation systems **A5.2** Appropriate choice of irrigation equipment by crop type, type and land cover

Table 11. Strategies to address barrier E3 - Lack of indirect financial incentives

Main Objective	Secondary objectives	Actions
To promote indirect financial incentives to treated WW reuse	Set-up TWW reuse networks close to farmers	**A1.1 :** Subsidize the implementation of infrastructures (transport, canals, irrigation systems ...)
		A1.2: Train farmers on the proper management of treated wastewater to avoid waste
	Ensure the farmer's hygiene	**A2.1:** Awareness campaigns on the use of TWWs and health security (through training days, workshops ...)
		A2.2: Provide the necessary equipment to guarantee the farmer's hygiene
	Ensure final product quality	**A3.1:** Subsidize phytotoxicity testing of products to ensure good quality for the consumer
		A3.2: Encourage farmers by giving them a certification

Table 12. Strategies to address barrier T3 - Lack of wastewater processing efficiency / undersized infrastructure / overload

Main Objective	Secondary objectives	Actions
To increase WW treatment efficiency and decrease the cases of plant overload	Monitoring the quality of effluent	A1.1: Control rejection (Prevention)
		A1.2: Pre-treatment (Prevention)
		A1.3: Train Personnel in the WWTWs
	Better management of treatment (minimize energy consumption while keeping the quality of effluent)	A2.1: Personal Training
		A2.2: Follow-up river and groundwater
		A2.3: Maintenance
	Treatment works dimensions, size, load	A3.1: public database of analyses
		A3.2: Decentralized tertiary treatment
		A3.3: low-cost polishing treatment
		A3.4: Adequacy process in use
		A3.5: nutrient value effluent in function USPGE / REJECTION / cost recovery -> m3
	Standards for monitoring and follow-up	A4.1: monitoring rejection
		A4.2: certification standardization laboratory / stations
		A4. 3: public database of analyses
		A4 .4: Effluent Nutrient Value in Function USPGE / REJECT / Cost Recovery -> m3
		A4.5: station pollution alerts
		A4.6: standardization methods of analysis

Table 13. Strategies to address barrier S1 : Lack of awareness on wastewater reuse

Main Objective	Secondary objectives	Actions
To promote the awareness of the advantages of TWW reuse among different users (agriculture, tourism, industry, municipal, ecological ...).	More positive evaluation of treated wastewater by farmers.	A1.1: Use the results of the study conducted by the Ministry of the Environment.
		A1.2: Update existing training/teaching materials (Guides, brochures, documentaries).
		A1.3: Relaunch awareness campaigns at national, regional and local level.
		A1.4: Identify and work with the relay population (champions).
		A.1.5: Organize visits for farmers to the model perimeters (Success Story).
		A.1.6: Inform about the regulatory texts relating to the REUT. (List of crops, health aspects).

	Valuation of treated wastewater in touristic sector	A2.1: Raising the awareness of Hoteliers and golf course promoters to the REUT (Information Day / Open House)
		A2.2: Sensitization on the scarcity of conventional water, adaptation to the impacts of climate change.

4.4 Evaluation of the mid-term SCWs by the participants

An evaluation of the mid-term SCWs was developed between the participants, based on 21 criteria. As can be observed in Figure 13, the feedback was generally positive.

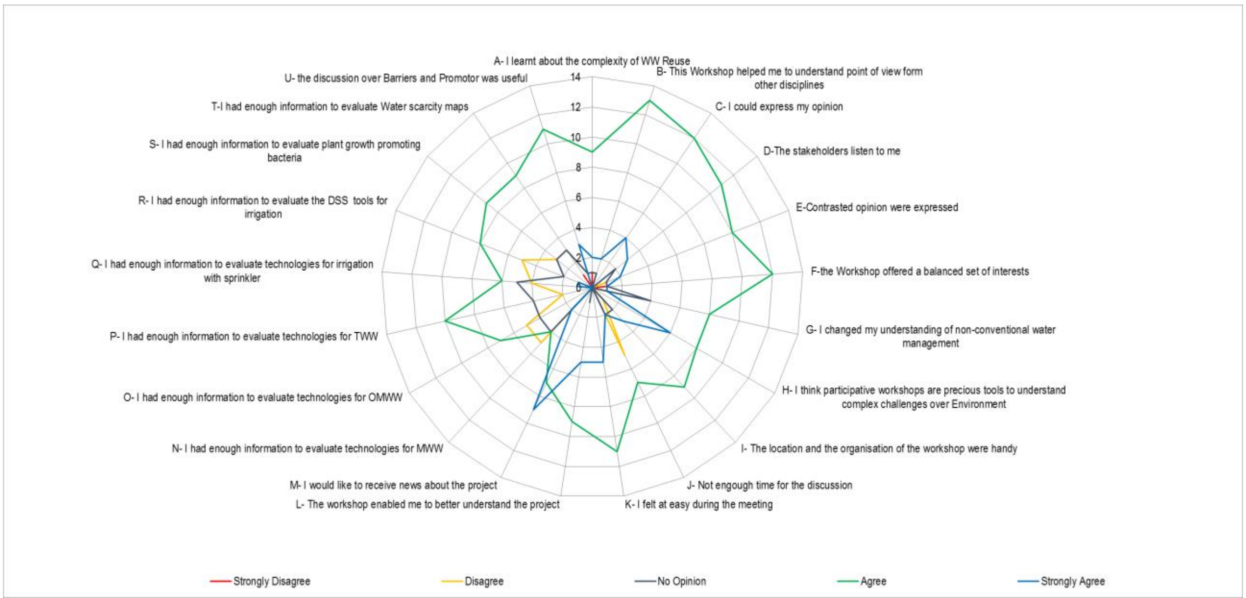


Figure 13. Stakeholders' evaluation of the mid-term SCW.

5 Opportunities and challenges for intensifying agricultural reuse of treated wastewater in the NENA region: the final SCW

5.1 General description

Date: 2nd April, 2019

Location: Cairo, Egypt

The final SCW was developed as a specific session during the FAO conference “Near East and North Africa Land and water days 2019”.

The objectives of the session were:

- to present to a broader audience the innovative and efficient irrigation technologies suitable for dry climates and for the use with treated wastewater, developed in the framework of MADFORWATER;
- to present model-based strategies to optimize cropping patterns and treated wastewater management in agriculture;
- to discuss the drivers and barriers for the implementation of innovative irrigation technologies and water management strategies addressing wastewater reuse for agriculture in the Near East and North African region.

Four panellists and 28 stakeholders from several Near East and North African countries participated to this SCW, that was articulated into 3 sections: in the 1st one, MADFORWATER researchers presented the main results relative to the project’s water management strategies and technologies, with specific focus on the irrigation technologies. The 2nd section consisted in a panel discussion, moderated by ALTER-WER, on how to maximize the effectiveness and impact of the MADFORWATER technologies and water management strategies, taking into account the specific features of the Tunisian, Moroccan and Egyptian context. The 3rd section consisted in questions and feedbacks form the participants to the session. The stakeholders that participated to the meeting of April 2019 were representatives of farmers’ associations, universities and research institutions, public institutions for agricultural management, water management institutions, environmental protection agencies, institutions for the monitoring of climate and climate change.

The board of panellists included experts from the International Water Management Institute (IWMI), the National Water Research Centre of Egypt and the Tunisian government (Ministry of Agriculture). Due to a last-minute problem, the board did not include any expert from Morocco. The panel discussion was moderated by Jochen Froebrich from WER (MADFORWATER partner).

5.2 Main outcomes from the panel discussion

The main barriers to the reuse of treated WW identified for Tunisia were the following:

- There is a governance issue, since in Tunisia 3 authorities are responsible for WW reuse: the Ministry of the Environment and the National Office of Sanitation of Tunisia (ONAS) are in charge of WW treatment, and the Ministry of agriculture is in charge of WW reuse.
- Psychological problems, low social acceptance and in some cases also religious barriers.

- WW treatment plants are typically located in cities, whereas agricultural reuse takes place in the countryside; this generates logistical difficulties and pumping costs.
- crops restriction: only trees or non-eatable crops are allowed to be irrigated with treated WW in Tunisia.
- the level of WW treatment is not sufficiently high in rural areas.

In Tunisia each governorate is involved in an action to promote the reuse of WW. A long-term master plan, started in January 2019, is in progress, with a horizon to 2050.

The main barriers to the reuse of treated WW identified for Egypt are the following:

- since most of the water in Egypt comes from outside the country, the best option is to increase water use efficiency and WW reuse locally, at the farmer level;
- low-cost but effective WW treatment technologies are required;
- the salinity problem is highly relevant and it could increase with treated WW reuse;
- there is a potential to use drainage canals for other uses, such as aquaculture.

The panellists and audience declared to be aware of the benefits of MADFORWATER technologies form the technical point of view, but for their adoption other issues arise, such as marketing (economic barriers to penetration in the MAC market) and the difficulties in inducing farmers to change their behaviours. Acceptance of innovative technologies, willingness to pay for them, and capacity to use them are also key issues, that can be overcome only by a widespread demonstration of the benefits to end users.

Economic incentives are necessary to boost the transition to new technologies. A distinction between capital and operational costs is required. Governments are often willing to pay for capital costs, but it is necessary to allow the recovery also of operational costs.

A crucial issue is related to the price of freshwater and treated WW. At the moment, farmers get freshwater for free or at very low prices in MAC country, therefore they are not incentive to switch to treated WW.

Regarding the use of an irrigation scheduling model, it is important to note that it is very difficult to convince farmers to change their irrigation habits. To do this, it is crucial that all stakeholders involved in its use understand how it works and to trust it. In other words, there is a strong need to build capacity.

Finally, most of the audience agreed that environmental costs associated to the switch to treated WW and to the implementation of innovative irrigation technologies should be included in the analysis.

6 Conclusions

An intense effort of stakeholder information and consultation was performed throughout the MADFORWATER project, in order to get a periodic feedback on the effectiveness and suitability of the project's technologies and water management strategies from North African experts with different backgrounds.

The main conclusions of this work can be summarized as follows:

- The identification of the most relevant stakeholders at the beginning of the project (stakeholder mapping) is a key element in order to address the consultation process in the correct direction.
- The organisation of regular SCWs allows a fluent communication and better understanding between the project partners and the relevant stakeholders. It is an essential tool to identify the main barriers and drivers and to get a constructive feedback on the suitability of the technologies in relation to the context where they have to be implemented, rather than on the technical aspects.
- The initial assessment of the perception of the stakeholders about the technologies to be implemented in the project reveals a low level of maturity of those technologies in the area, especially the ones related with WW treatment. This information was used to better design the implementation process. The subsequent evaluation shows that stakeholder perception over those technologies improved along the project thanks to the dissemination activities developed.
- Numerous barriers and drivers were identified for a sustainable WW reuse for irrigation in the 3 target countries. There are great similarities in the type of barriers and the approach to cope with them between the countries.
- The most relevant barriers identified were: a) the lack of financial incentives to treated WW reuse; b) the lack of an institution of coordination between the different institutions involved in treated WW reuse; c) poor governance at the level of the farmers' unions; d) lack of awareness on the advantages of WW reuse, and e) lack / undersizing of suitable wastewater treatment infrastructures.
- A crucial issue to boost the penetration of WW reuse is the price of water, since in most MAC countries fresh water is almost free, while treated WW usually has a cost. Water pricing policies must be designed in order to stimulate farmers to switch to treated WW.
- Finally, it can be concluded that most of the stakeholders involved in the MADFORWATER workshops recognize the potential benefits of the MADFORWATER technologies from a technical point of view. However, several stakeholders highlighted that the actual implementation and impact of these technologies depends on the efficient tackling of critical issues, such as the economic barriers to the penetration of innovative technologies in the MAC market and the difficulties in inducing farmers to change their behaviours. Acceptance of innovative technologies, willingness to pay for them and capacity to use them are key issues, that can be overcome only by a widespread demonstration to end users of the benefits of the proposed technologies. Under this perspective, the numerous capacity building activities performed by MADFORWATER partners and the implementation of selected technologies in field pilot plants installed in Tunisia, Egypt and Morocco represent crucial steps in order to overcome the above-mentioned barriers.

7 Symbols and abbreviations

CIS	Common Implementing Strategy
IWRM	Integrated Water Resource Management
MACs	Mediterranean African Countries
NENA	Near East and North Africa
NGO	Non-Governmental Organisation
SAB	Stakeholder Advisory Board
SCWs	Stakeholder Consultation Workshops
TWW	Treated wastewater
WFD	Water Framework Directive
WW	Wastewater

8 Bibliography

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9 Annex

9.1 Annex A. Initial Stakeholder questionnaire

Note: the questionnaire showed below was adapted from its original format by eliminating the space for answering in order to minimize the number of pages.

MAD4WATER - 1st stakeholder questionnaire

INTRODUCTION TO THE MADFORWATER PROJECT

You have been invited to participate to the Stakeholder Advisory Board of an EC-funded research project called "*DevelopMent AnD application of integrated technological and management solutions FOR wasteWATER treatment and efficient reuse in agriculture tailored to the needs of Mediterranean African Countries – MADFORWATER*" involving Partners from Egypt, Tunisia and Morocco and coordinated by the University of Bologna under the H2020 European Research Programme. The project lasts 48 months (June 2016- May 2020). We really appreciate your interest in this project and the time that you will dedicate to it.

The general goal of the project is to develop an integrated set of technological and management instruments for the enhancement of wastewater treatment, treated wastewater reuse for irrigation and water efficiency in agriculture, with the final aim to reduce water vulnerability in selected basins in Egypt, Morocco and Tunisia. The selected basins are: North Eastern Nile Delta in Egypt, Cap-Bon and Miliane in Tunisia, Souss-Massa in Morocco.

You can find detailed information about the project in its website (www.madforwater.eu), that we encourage you to visit and read, and in the introductory presentation attached to this questionnaire. Furthermore, you can find a short description of the Madforwater wastewater treatment and irrigation technologies in sections B and C of this questionnaire.

One of the key aspects of Madforwater is the development of technologies and water management strategies well adapted to and suited for the local context of the selected basins in Egypt, Morocco and Tunisia. All adaptation actions will be characterized by a participatory approach, ensured by the involvement of relevant stakeholders through the Stakeholder Advisory Board (SAB).

This questionnaire represents the first step of the stakeholder-based adaptation approach. The aim of the questionnaire is to gather information on the level of water vulnerability in Egypt, Morocco and Tunisia, and in particular to identify the needs and gaps in terms of (1) development and adaptation to the local context of wastewater (WW) treatment, irrigation technologies and treated WW reuse in agriculture, and (2) development and implementation of strategies, economic instruments and policies in the field of water management. In other words, we aim at investigating the factors that influence the development and application of technologies and management tools in the field of water management. Factors that prevent (negative influence) such development are called Barriers, and those that encourage it (positive influence) the reuse are called Drivers.

CONFIDENTIALITY

Madforwater aims to build recommendation for local policy makers and the EC on a participative manner with the elicitation of local stakeholder's perception of barriers and drivers.

Raw data, i.e. individual answers, will be only handled by Alterra- Stichting Dienst Landbouwkunding Onderzoek (Wageningen University and Research), and will be kept strictly confidential. Identities of respondents will be kept confidential and will not appear in the reports. Questionnaires will be processed to produce recommendations according to the Description of Action of the Madforwater project at country level. Your personal data will be processed by the authorized research staff only for scientific purposes, and without allowing Your identification. Alterra- Stichting Dienst Landbouwkunding Onderzoek (Wageningen University and Research) is the data controller and processor. Alterra and the Madforwater team will disseminate the aggregated and re-elaborated answers in a completely anonymous way, and not the individual answers. Your participation is voluntary. You will be free to withdraw from the participation in the Project at any time without giving a reason and without negative consequences. In case of withdraw, all personal data you gave will be discarded. Hence By filling the questionnaire you accept these conditions.

HOW TO ANSWER THE QUESTIONNAIRE?

- If you are a stakeholder from Egypt, Morocco and Tunisia, refer your answer only to your country. If you are not from these countries, you can refer your answers either to the overall North African situation or to a specific country, if you have a specific knowledge relative to one of these 3 countries. Alternatively, you can also provide multiple answers, one for each target country of Madforwater. We ask you to specify your choice.
- If you want to refer to a specific area / basin of your country for one or more answers, feel free to do it, but specify this in your answer.
- Depending on your field of expertise, feel free to fill in all the questionnaire or only specific sections.
- There is no right or wrong answer. Answer according to your knowledge and your opinions. You have been selected because you are an expert so feel free to give your own opinion.

CONTROLS:

Gender:

Man..1
Woman 2

Age:

18- 25...1
26-35...2
36-45...3
46-55...4
56-65...5
65+ 6

Profession

Job title____
Responsibility____
Institution or employer___________________________________

Public institution/ administration	1
Private company or business	2
NGO	3

Part A: Adaptation to the local context of WW technologies

In MAD4WATER, 11 wastewater treatment technologies are developed and adapted to the local context. These technologies are designed for different WW types: municipal, agro-industrial (olive mill WW and fruit / vegetable packaging WW) and industrial (textile WW). In addition, 1 technology (n. 1) is also targeted to the treatment of drainage canal water, typical of the Egyptian context.

A.1 WW treatment technology 1: Canalized lagoon with nitrification/denitrification and disinfection capacity, for the tertiary treatment of municipal WW and for the treatment of drainage canal water.

Canalized facultative lagoons are characterized by the alternation of aerobic and anoxic zones, that make them suitable for nitrification / denitrification processes and biological removal of BOD and phosphorous. In North African countries, thanks to the strong solar radiation, they can also perform a very effective disinfection. They can also be used as reservoirs, to store irrigation water to be used during dry seasons. In the Egyptian context, the goal of Madforwater is to optimize the use of the drainage canals receiving drainage water and local WWs as canalized facultative lagoons, through proper design in terms of geometry and fluid dynamics.

A1.1. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.2. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country ?

Yes No I don't Know

A.2 WW treatment technology 2: Nitrifying trickling filters filled with innovative high specific-surface carriers, for the secondary treatment of municipal WW.

In case of medium and small communities, trickling filters can represent an interesting alternative to activated sludge plants, thanks to the small or null energy consumption required for WW aeration. While traditional trickling filters are characterized by high retention times and poor nitrification / denitrification performances, Madforwater will develop and implement filters characterized by innovative high-surface carriers so as (i) to reduce retention times thanks to the attainment of a high biofilm thickness, and (ii) to improve the nitrification / denitrification performances.

A1.3. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.4. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.3 WW treatment technology 3: Constructed wetlands with plant growth promoting bacteria, for the tertiary treatment of municipal WW.

Constructed wetlands have the potential to remove priority pollutants, nitrogen, phosphorous, heavy metals and residual BOD, thanks to the combined effect of plants and of the rhyzosphere's microbial community. The coexistence of anoxic–aerobic–anaerobic microenvironments favours different removal mechanisms. Plant growth promoting bacteria can play a key role in constructed wetlands by actively cooperating with plants in the degradation process.

A1.5. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.6. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.4 WW treatment technology 4: Enzymatic degradation of emerging pollutants, dyes and fungicides with immobilized laccases, for the tertiary treatment of municipal WW, textile WW and fruit / vegetable packaging WW.

WW treatment technologies based on immobilized enzymes can be of particular interest for dyes removal from textile WW, fungicide removal from fruit and vegetable packaging WW and micropollutants removal from municipal WW, because of their extreme selectivity in comparison to other advanced oxidation processes and to adsorption. Indeed, the latter processes are quite unspecific and do not allow for a targeted removal of micropollutants. In addition, laccases do not require co-factors, and reusability and robustness of immobilized laccases are demonstrated. Laccase enzyme production can make use of simple and cheap fermentation technologies (e.g. solid state fermentation) and costs might be decreased in the African context by targeting at a local production, using cheap agroindustrial residues available hyperproducing strains (several thousands of U/mL). Costs of the WW treatment process may also be reduced by considering packed bed systems rather than membrane bioreactors. Immobilization is simple, fast and reproducible, and does not require enzyme purification (crude enzymes could be used, thus lowering the costs). The selected immobilization support is also cheap, as it is derived from fumed silica (aggregates of nanoparticles).

A1.7. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.8. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.5 WW treatment technology 5: Catalytic disinfection beds activated by solar UV light, for the treatment of municipal WW.

WW disinfection by means of UV-activated catalytic beds a low-cost, low-environmental impact effective alternative to conventional disinfection systems. They are well adapted to the local conditions of the North African context. During night time the effluents will be stored in a holding tank and treated during daytime. The actual pathogen removal will be monitored by quantifying fecal coliforms, Adenovirus, Rotavirus, Norvovirus and Enterovirus by q-PCR.

A1.9. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.10. Do you consider that this WW treatment technology is performing adequate in your country?

Yes No I don't Know

A.6 WW treatment technology 6: Flotation / flocculation integrated process, for the treatment of fruit / vegetable packaging WW.

Flotation represents an interesting alternative to sedimentation, thanks to the reduced treatment volumes and to the increased treatment efficiency. The combined flotation / flocculation process proposed by Madforwater allows the attainment of high removal efficiencies not only for suspended solids but also for BOD. It is characterized by a very low HRT (3-4 minutes), a low recycle ratio and a low energetic consumption.

A1.11. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.12. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.7 WW treatment technology 7: Membrane filtration + phenolic compounds adsorption with selective resins + anaerobic digestion in biofilm reactor, for the treatment of olive mill WW.

Several types of processes were proposed in the literature to treat olive mill WW: membrane processes, adsorption / desorption, cloud point extraction with surfactants, solvent extraction, aerobic biodegradation combined with CaO addition, anaerobic digestion. However, none of these processes was scaled-up to real-scale low-cost applications, so far. The process proposed by Madforwater is close to industrial application. It can produce a final effluent suitable for irrigation, and each step leads to a specific olive mill WW valorisation: olive paté from filtration, polyphenol-rich mixtures characterized by high anti-oxidant properties from adsorption/desorption, electricity and heating from anaerobic digestion. Adsorption/desorption will be characterized by the complete recycling of the desorption solvent. Anaerobic digestion can be performed in possible co-digestion and/or alternation with other wastes typical of the North African context.

A1.13. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.14. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.8 WW treatment technology 8: Aerobic sequenced batch reactor (SBR) with lime addition, for the treatment of olive mill WW.

The SBR process presents several potential advantages in comparison to traditional aerobic processes. The implementation of an aerobic SBR process for the treatment of olive mill WW is of particular interest, on the basis of the pilot-scale studies performed by Madforwater partners. To minimize the energetic consumption associated to oxygenation, a novel high-efficiency air distribution system based on the production of micro-bubbles will be implemented in this SBR process.

A1.15. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.16. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.9 WW treatment technology 9: Granulated sludge bioreactor, for the treatment of textile WW.

Aerobic granulated sludge was proposed in recent years as a compact, robust and low energy consuming WW secondary treatment technology for industrial effluents. MADFORWATER will address the potential weaknesses of granulated sludge aerated bioreactors, by developing stable consortia adapted to the treatment of real textile WW, and by investigating the mechanisms of granular sludge formation and the factors ensuring its stability.

A1.17. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.18. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.10 WW treatment technology 10: Moving Bed Biological Reactor, for the treatment of textile WW.

The Moving Bed Biological Reactor (MBBR) is finding increasing applications at industrial scale, for the treatment of high-load WWs. Its application to the treatment of textile WW is innovative, and could potentially lead to a significant reduction of the treatment costs. A two-stage (anaerobic/aerobic) MBBR will be developed, with the aerobic step aerated by a novel oxygenator of Nanotera Group.

A1.19. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.20. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

A.11 WW treatment technology 11: Textile WW treatment by adsorption with innovative resins.

The proposed adsorption/desorption process aims at the removal of aromatic amines, brown color and metals. Magnetic polyacrylic microspheres previously developed by the Chinese Madforwater partner (NJU) will be adapted, by modifying pore size and functional groups. An online UV/Fluorescence sensor, designed to monitor aromatic amines and chromophores, will be integrated into the system as a feedback signal, to achieve an automatic optimization of operational parameters. The possibility to re-utilize the desorbed material in the textile industry will be evaluated. The performances will be compared with those obtained with advanced oxidation processes (electrolytic treatment with Boron-doped diamond electrodes), taken as a benchmark technology.

A1.21. Do you consider that this WW treatment technology is effective to produce irrigation water?

Yes No I don't Know

A1.22. Do you consider that this WW treatment technology is suitable, in relation to the specific context of your country?

Yes No I don't Know

Part B: Adaptation to the local context of irrigation technologies

In MAD4WATER, 6 irrigation technologies are designed specifically to work with treated WW, even though the can effectively function with conventional irrigation water (groundwater, surface water).

C.1 Irrigation Technology 1: Increased crop resistance to water scarcity and salinity through the addition of plant growth promotion bacteria to the irrigation water.

Plant growth promoting (PGP) microbes can support plant growth under harsh conditions typically occurring in extreme environments, such as drought and soil salinity. However, their application to promote crop productivity is still poorly applied at large scale. Madforwater will develop and apply site-tailored PGP inocula as biofertilizers for selected crops of high economical interest for the target countries. The inocula will be not only endowed with plant-growth activities but also well adapted and efficient in the context of WW reuse in stressed and arid lands characteristic of the target countries.

C1.1. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.2. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

C.2 Irrigation Technology 2: Low-pressure mini-sprinkler adapted to dry climates and to treated WW.

A low-cost innovative mini-sprinkler suitable for treated WW, low skilled farmers and high evaporative climates, typical of the target countries, will be developed. The proposed innovative mini-sprinkler will be characterized by high resistance to clogging and minimum risk of farmer/edible part contact with treated WW. The best combinations of mini-sprinkler nozzle size and design, operating pressure and droplet size distribution will be analyzed experimentally at field scale with actual treated WW. Thanks to the reduction in water evaporation and resistance to wind drift, the mini-sprinkler is expected to lead to an increase in water use efficiency compared to a traditional sprinkler of at least 10%.

C1.3. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.4. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

C.3 Low-pressure calibrated nozzle adapted to dry climates and to treated WW.

This irrigation technology is intermediate between the traditional gravity systems and the modern drip irrigation systems, too expensive and fragile for the target countries. It combines the advantages of the low cost and easiness of use of gravity systems with the high application efficiency of the localized drip system. To minimize energy and maintenance cost, the design will be adapted to operate at low pressure (around 0.5 bar). The high discharge rate of the proposed nozzle will largely reduce emitters fouling and clogging (a common problem when irrigating with poor water quality), but at the same time it might increase runoff losses. To overcome this problem, the proposed system will be coupled with a pulsed irrigation technique so as to meet but not exceed the moisture need of each plant. The nozzle design will rely on a computational fluid dynamic (CFD) approach. The expected increase in water efficiency use is equal to 15%, in comparison with gravity systems.

C1.5. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.6. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

C.4 Irrigation Technology 4: Re-engineered surface irrigation systems based on calibrated gated pipes (only for the Egyptian case study).

Mesqas are small traditional irrigation canals (50-100 L/s) widely used in Egypt to convey drainage canal water (DCW) to the fields. Due to the widespread over-irrigation practice, the quality of irrigation water gradually deteriorates as the contribution of drainage water from upstream fields into the Mesqa increases. Madforwater will optimize the replacement of traditional mesqas with an innovative, more efficient system expected to improve conveyance (evaporation, infiltration and weed development), water application (better uniformity and less leaching) and crop productivity. Cheap systems consisting in PVC pipes fitted with calibrated gate valves and with calibrated nozzles will be investigated as a technical (easy to install and to operate) and economical (low capital and operational cost) solution, potentially accepted by Egyptian farmers to replace their traditional Mesqas system. The gated pipe and the calibrated nozzle systems will be comparatively tested at field scale, under conditions that mimic Mesqas. The systems will be tested for uniformity, efficiency and adequacy with different slopes, pressures and pipe lengths. A design and performance analysis tool in the form of an OpenOffice spreadsheet or stand-alone software will be developed, in order to support the subsequent implementation of the most effective system.

C1.7. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.8. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

C.5 Irrigation Technology 5: Large spectrum soil moisture sensor calibrated for saline water.

Soil tensiometers, that measure the energy required by plants to extract water from soil, are widely used and successful tools for irrigation scheduling. However, the currently available tensiometers operate within a limited suction force interval (0-3 bar) and they are subjected to dysfunctioning when used under salinity condition. In the framework of Madforwater, an upgraded tensiometer that can operate in a wider suction force range (> 5 bar) and under the high-salinity levels typical of treated WW will be developed and evaluated under laboratory conditions (soil samples watered with controlled salinity levels) and field conditions (fields irrigated with real treated WW). The first season will be dedicated to the evaluation of the innovative tensiometer to withstand high salinity levels, whereas the second season will be aimed at testing of the capacity of the sensor to schedule irrigation with treated WW.

C1.9. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.10. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

C.6 Irrigation Technology 6: Open source software tool to determine the optimal irrigation amount and schedule.

An open source a modeling tool capable to identify the optimal water and nutrient application scheduling for crops irrigated in arid climates and with treated WW will be developed. The model will receive as input local meteorological data, soil type, soil moisture content, treated WW composition, crop type and phenological stage. Leaching requirement to avoid salinity build up in soil and hence yield reduction will be considered. The amount of fertilizers required will be estimated on the basis of the nutrient content of water. The model will be adapted to account for the improvements in crop water use and plant tolerance to salt associated to the supply of PGP bacteria (irrigation technology 1). The proposed modeling tool will enclose water balance and nutrient/microbial movement models. It will be developed as a stand-alone software with Graphical User Interface (GUI), supported by a technical manual in English and French. The model can be used to provide daily personalized information on the irrigation and nutrient supply schedule by SMS or email to farmers who subscribe to the service.

C1.11. Do you consider that this irrigation technology is effective to irrigate crops with treated WW?

Yes No I don't know

C1.12. Do you consider that this irrigation technology is suitable, in relation to the specific context of your country?

Yes No I don't know

Part C: Comprehensive evaluation of barriers and drivers in the field of water management, with specific focus on treated WW reuse

This questionnaire includes a list of factors that can favour and boost water management. These factors are articulated into 5 categories.

Having a **critical view** of the **current situation in your country**, please whether each factor, on the basis of its level of current level of development and implementation, represents a barrier or a driver. In particular we ask you to rate each factor as specified below:

- if the factor is considered a **barrier**: B1= low barrier, B2= moderate barrier, B3 = major barrier
- if the factor is considered a **driver**: D1= low driver, D2= moderate driver, D3= major driver
- I don't know= 0

Policy factors	**Ranks** **B3, B1, B1, 0, D1, D2, D3**
P1. National / regional policies on Water Resources Management (WRM)	
P2. National / regional environmental policies	
P3. Land use policies	
P4. Transnational or transboundary treaties & agreements	
P5. Trade policies (exports of agricultural products)	
P6. Agricultural policy	
Add your suggestions for further policy factors	
Economic factors	
E1. Availability of governmental & public funds	
E2. Indirect financial incentives	
E3. Freshwater pricing schemes for food-crop irrigation	
E4. Freshwater pricing schemes for non-food crop	
E5. Freshwater pricing schemes for industrials uses	
E6 Drinking water pricing schemes	
E6. Farm operating costs (pumping cost of surface GW)	
E7. Farm investment cost of irrigation technologies	
Add your suggestions for further economy factors	

Social factors	
S1. Public awareness on water scarcity problems	
S2. Public awareness on treated wastewater reuse as a resource	
S3. Public perceptions on the consumption of crops irrigated with reclaimed water	
S4. Involvement of different stakeholder groups in decision-making processes	
Add your suggestions for further social factors	
Technical factors	
T1. Technical expertise & know-how on wastewater (WW) treatment & supply	
T1.1 For the irrigation of food crops	
T1.2 For the irrigation of non-food crops	
T1.3 For unrestricted urban uses	
T1.4 For restricted urban uses	
T1.5 For industrial processes	
T2. Technical expertise & know-how on using reclaimed water	
T2.1 For farmers and field workers	
T2.2 For industries	
T2.3 For urban citizens	
T3. Irrigation systems used	
Add your suggestions for further technical factors	
Legal & institutional factors	
L1. Ownership of treated WW – Water rights law	
L2. Regulatory framework on treated wastewater reuse	
L3. Enforcement of regulations and laws	
L4. Delineation of responsibilities among the institutions involved in water & WW management	
L5. Communication between ministries	
L6. Communication between decision makers and end-users	
L7. Capacities of decision makers to change laws and practices	
Add your suggestions for further legal factors	

9.2 Annex B. Mid-term Stakeholder questionnaire: irrigation technologies

Note: the questionnaire showed below was adapted from its original format by eliminating the space for answering in order to minimize the number of pages.

Dear stakeholder

Thanks a lot for participating to this meeting and filling in this questionnaire.

The purpose of the questionnaire is to **evaluate whether the irrigation technologies that MADFORWATER is developing are suitable for the local context of your country / governorate / basin**, making reference in particular to their use with treated wastewater. In other words, if you think that these technologies can find actual implementation, by effectively replacing or integrating the irrigation technologies currently used.

Information on the stakeholder

Country / governorate / basin: ____

Field of professional activity: ____

Professional role: ____

Other useful information that you would like to provide on yourself: ______________

TECHNOLOGY 1: MICRO SPRINKLER, An efficient low-pressure anti-drift micro sprinkler adapted to treated wastewater

1 - Is this technology suitable for your country / governorate / basin in terms of type of required farmer skills and easiness of operation and maintenance?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not know

Please justify / explain your answer:

____

2 - Is this technology suitable for your country / governorate / basin in terms of pumping energy consumption in regard to traditional techniques?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not know

Please justify / explain your answer:

____

3 - Is this technology suitable for your country / governorate / basin from a **cultural point of view?** In other words, do you think that this technology can be easily accepted by the local population?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not KNOW

Please justify / explain your answer: ____

4 - Is this technology suitable for your country / governorate / basin from a **safety point of view,** in particular in relation to its use with treated wastewater?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not know

Please justify / explain your answer: ____

5 - Do you have any further comments, or any suggestions on how to improve this technology and thus to increase its chances to find actual implementation in your country / governorate / basin?

TECHNOLOGY 2: ANTI-LEAKAGE CALIBRATED IRRIGATION NOZZLE, a localized irrigation emitter resistant to clogging

[Questions 1 to 5 as in technology 1]

TECHNOLOGY 3: MODELING TOOL FOR OPTIMAL IRRIGATION SCHEDULING WITH DIFFERENT WATER TYPES

1 - Are computer models used for irrigation scheduling optimization in your institution / agency / farm?

1) Not at all
2) Poorly
3) Reasonably
4) Highly
5) I do not know

Please justify / explain your answer: ____

2 - Are input data to these models usually available?

1) Not at all
2) Poorly
3) Reasonably
4) Highly
5) I do not know

Please justify / explain your answer:

____

3 - Could this model help to develop "scenarios and alternatives" for best management practices by using low water quality?

1) Not at all
2) Poorly
3) Reasonably
4) Highly
5) I do not know

Please justify / explain your answer:

____

4 - Do the results of this type of model represent an effective guide to take decisions on irrigation practices?

1) Not at all
2) Poorly
3) Reasonably
4) Highly
5) I do not know

Please justify / explain your answer:

____

5 - Do you have any further comments, or any suggestions on how to improve this technology and thus to increase its chances to find actual implementation in your country / governorate / basin?

____

TECHNOLOGY 4: PLANT GROWTH PROMOTING (PGP) BACTERIA TO ENHANCE CROP RESISTANCE TO WATER STRESS AND SALINITY

1 - Acceptability of this technology from a cultural and ethical point of view: Would this technology be accepted by farmers and the end-users in general? (critical opinion of people...)

1) Not acceptable at all
2) Poorly acceptable
3) Reasonably acceptable
4) Highly acceptable
5) I do not KNOW

Please justify / explain your answer:

___

2 - Would be there any constraints from a legal and administrative point of view that could hinder the actual implementation of this technology?

1) Not at all
2) Poorly
3) Reasonably
4) Highly
5) I do not KNOW

Please justify / explain your answer:

___

3 - Is this eco-friendly and sustainable technology suitable for your country / governorate / basin from a safety and economically point of view?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not know

Please justify / explain your answer:

___

4 - Is it necessary to invest additional efforts to increase farmer's skills needed to implement this technology?

1) Not necessary at all
2) Poorly necessary
3) Reasonably necessary
4) Highly necessary
5) I do not KNOW

Please justify / explain your answer:

___

5 - Which are the crops that could particularly benefit from this technology in your country / governorate / basin?

___

6 - Do you have any further comments, or any suggestions on how to improve this technology and thus to increase its chances to find actual implementation in your country / governorate / basin?

___

9.3 Annex C. Mid-term Stakeholder questionnaire: wastewater treatment technologies

Note: the questionnaire showed below was adapted from its original format by eliminating the space for answering in order to minimize the number of pages.

Dear stakeholder

Thanks a lot for participating to this meeting and filling in this questionnaire.

The purpose of the questionnaire is to **evaluate whether the wastewater technologies that MADFORWATER is developing, and their combination into possible treatment trains, are suitable for the local context of your country / governorate / basin**. In other words, if you think that these technologies can find actual implementation, by effectively replacing or integrating the technologies currently for the different wastewater types targeted by MADFORWATER.

For each wastewater type, the questionnaire is articulated into 3 sections:

A) Evaluation of the **possible treatment trains** that MADFORWATER is developing

B) Evaluation of the **single technologies** that MADFORWATER is developing

C) Collection of general information on each wastewater type, relatively to your country.

Information on the stakeholder

Country / governorate / basin: ____

Field of professional activity: ____

Professional role: ____

Other useful information that you would like to provide on yourself: _____________

1) MUNICIPAL WASTEWATER

SECTION A - EVALUATION OF THE POSSIBLE TREATMENT TRAINS

A1 - Treatment train 1: Trickling filters → sedimentation → chemical disinfection → removal of pharmaceuticals in enzyme bioreactors. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A2 - Treatment train 2: Trickling filters → sedimentation → chemical disinfection → removal of heavy metals and pharmaceuticals in constructed wetlands. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A3 - Do you have any further comments or suggestions on the proposed treatment trains, in order to increase their chances to find actual implementation in your country / governorate / basin?

____

SECTION B: EVALUATION OF THE SINGLE TECHNOLOGIES THAT MADFORWATER IS DEVELOPING FOR THE TREATMENT OF THIS WASTEWATER TYPE

TECHNOLOGY 1: NITRIFYING TRICKLING FILTERS

B1 - Is this technology suitable for your country / governorate / basin in terms of type of skills required for operation and maintenance?

6) Not suitable at all
7) Poorly suitable
8) Reasonably suitable
9) Highly suitable
10) I do not know

Please justify / explain your answer:

____

B2 - Is this technology suitable for your country / governorate / basin in terms of costs for operation and maintenance?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable
4) Highly suitable
5) I do not know

Please justify / explain your answer:

____

B3 - Is this technology suitable for your country / governorate / basin in terms of availability of required reagents and spare parts?

1) Not suitable at all
2) Poorly suitable
3) Reasonably suitable

4) Highly suitable
5) I do not know

Please justify / explain your answer:

___

B4 - Is this technology suitable for your country / governorate / basin from a **safety point of view?**

6) Not suitable at all
7) Poorly suitable
8) Reasonably suitable
9) Highly suitable
10) I do not know

Please justify / explain your answer:

___

B5 - Is this technology suitable for your country / governorate / basin from a **cultural point of view?** In other words, do you think that this technology can be culturally accepted by the local population?

6) Not suitable at all
7) Poorly suitable
8) Reasonably suitable
9) Highly suitable
10) I do not know
11) Not applicable to this technology

Please justify / explain your answer:

___

B6 - Is this technology suitable for your country / governorate / basin from a **legal point of view?** Are there any legal constraints that could hinder the actual implementation of this technology?

6) Not suitable at all
7) Poorly suitable
8) Reasonably suitable
9) Highly suitable
10) I do not know
11) Not applicable to this technology

Please justify / explain your answer:

___

B7 - Do you have any further comments, or any suggestions on how to improve this technology and thus to increase its chances to find actual implementation in your country / governorate / basin?

___

TECHNOLOGY 2: CONSTRUCTED WETLANDS for the removal of metals and emerging organic contaminants

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 3: IMMOBILIZED ENZYME BIOREACTORS for the removal of pharmaceuticals

[Questions B1 to B7 as in p. 3-4]

SECTION C: GENERAL INFORMATION ON MUNICIPAL WASTEWATER IN YOUR COUNTRY

In this section we are asking for information at country level. If prefer to provide information relative to your basin / province / governorate instead of your country, feel free to do so, we just ask you to specify it.

C1 – The data provided are relative to (specify the country, basin or governorate):

____

C2 - Amount of this type of wastewater produced (m^3/year):

____

C3 - Indicative % of produced wastewater that receives an adequate treatment:

____

C4 - Main technologies used for the treatment of this wastewater:

____

C5 - Main obstacles related to the treatment of this wastewater:

____

C6 - Main obstacles related to the agricultural reuse of this wastewater, after its treatment:

____

C7 - Who pays for the treatment of this wastewater:

____

C8 - (only for non-municipal wastewaters) Is this wastewater generally:

a) completely treated at the production site, without any discharge in the sewer system

b) pre-treated at the production site, and then discharged in the sewer-system

c) discharged in the sewer system without any pre-treatment

d) re-used in agriculture or released in other water bodies without any treatment

2) OLIVE MILL WASTEWATER

SECTION A - EVALUATION OF THE POSSIBLE TREATMENT TRAINS

A1 - Treatment train 1: Suspended solids removal by microfiltration → polyphenol recovery by adsorption → BOD removal by biomethanation. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A2 - Treatment train 2: Aerobic biological treatment in a sequenced batch reactor with lime addition. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A3 - Do you have any further comments or suggestions on the proposed treatment trains, in order to increase their chances to find actual implementation in your country / governorate / basin?

____

SECTION B: EVALUATION OF THE SINGLE TECHNOLOGIES THAT MADFORWATER IS DEVELOPING FOR THE TREATMENT OF THIS WASTEWATER TYPE

TECHNOLOGY 1: MICROFILTRATION AND POLYPHENOL RECOVERY BY ADSORPTION

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 2: ANAEROBIC DIGESTION

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 3: AEROBIC BIOLOGICAL TREATMENT IN A SEQUENCED BATCH REACTOR

[Questions B1 to B7 as in p. 3-4]

SECTION C: GENERAL INFORMATION ON OLIVE MILL WASTEWATER IN YOUR COUNTRY

[Foreword + questions C1 to C8 as above in p. 7-8]

4) TEXTILE WASTEWATER

SECTION A - EVALUATION OF THE POSSIBLE TREATMENT TRAINS

A1 - Treatment train 1: Coagulation / flocculation → moving bed biological reactor (MBBR) → dyes enzymatic degradation in packed bed reactors with immobilized laccases. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A2 - Treatment train 2: Coagulation / flocculation → moving bed biological reactor (MBBR) → dyes adsorption/desorption with innovative magnetic resins. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A3 - Do you have any further comments or suggestions on the proposed treatment trains, in order to increase their chances to find actual implementation in your country / governorate / basin?

____

SECTION B: EVALUATION OF THE SINGLE TECHNOLOGIES THAT MADFORWATER IS DEVELOPING FOR THE TREATMENT OF THIS WASTEWATER TYPE

TECHNOLOGY 1: MOVING BED BIOLOGICAL REACTOR

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 2: IMMOBILIZED ENZYME BIOREACTORS FOR DYE DEGRADATION

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 3: DYE ADSORPTION ON INNOVATIVE RESINS

[Questions B1 to B7 as in p. 3-4]

SECTION C: GENERAL INFORMATION ON TEXTILE WASTEWATER IN YOUR COUNTRY

[Foreword + questions C1 to C8 as above in p. 7-8]

4) FRUIT AND VEGETABLE PACKAGING WASTEWATER

SECTION A - EVALUATION OF THE POSSIBLE TREATMENT TRAINS

A1 - Treatment train 1: Moving bed biofilm reactor (MBBR) to remove organic contaminants → Integrated flotation and flocculation to remove suspended solids → UV-Oxidation/Immobilised enzymes to remove residual fungicides. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A2 - Treatment train 2: Moving bed biofilm reactor (MBBR) to remove organic contaminants → Integrated flotation and flocculation to remove suspended solids → Activated carbon to remove residual fungicides. How do you rate this treatment train in relation to the specific needs and characteristics of this wastewater and of your country / governorate / basin?

1. Not suitable at all
2. Poorly suitable
3. Reasonably suitable
4. Highly suitable
5. I do not know

A3 - Do you have any further comments or suggestions on the proposed treatment trains, in order to increase their chances to find actual implementation in your country / governorate / basin?

____

SECTION B: EVALUATION OF THE SINGLE TECHNOLOGIES THAT MADFORWATER IS DEVELOPING FOR THE TREATMENT OF THIS WASTEWATER TYPE

TECHNOLOGY 1: AEROBIC MOVING BED BIOREACTOR (MBBR)

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 2: INTEGRATED FLOTATION & FLOCCULATION

[Questions B1 to B7 as in p. 3-4]

TECHNOLOGY 3: UV-OXIDATION WITH TIO2–COATED BEDS COMBINED TO IMMOBILIZED ENZYME BIOREACTORS

[Questions B1 to B7 as in p. 3-4]

SECTION C: GENERAL INFORMATION ON FRUIT AND VEGETABLE PACKAGING WASTEWATER IN YOUR COUNTRY

[Foreword + questions C1 to C8 as above in p. 7-8]