University of Applied Sciences Northwestern Switzerland
School of Life Sciences

Handbook

Poseidon 2.0 – A tool to Promote and Assess Water Reuse

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1. Preface

This developed Excel-Tool is an Excel file which contains macros. You can open this file type like usual Excel files. However, the following Security Warning message appears:

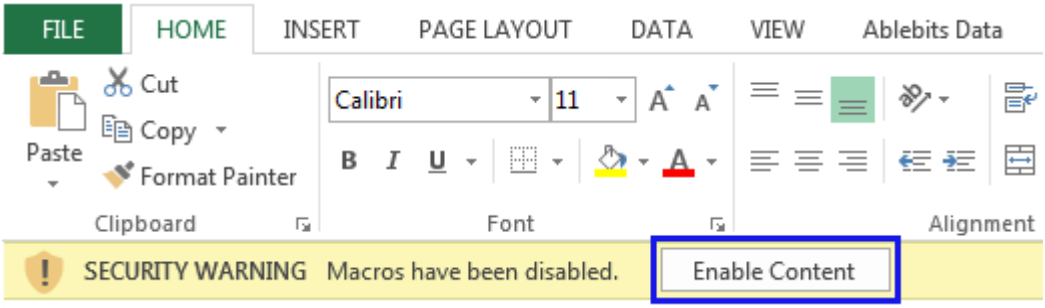


Figure 1: Excel Macro Security Warning Message.

Click the "Enable Content" button for the developed Excel-Tool to work. These are simple macros, which give a better overview while simplifying the usage.

2. Introduction

Poseidon 2.0 has been developed in the frame of the EU Horizon 2020 project MADFORWATER[1], which aims 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 challenge of reuse and recycling technology projects is not the lack of treatment techniques and technologies but rather lies in how such schemes may be implemented in the local context.

Poseidon 2.0 itself is a user-oriented, simple, and efficient Excel-Tool, which aims to compare different wastewater treatment techniques based on their removal efficiencies, their costs, and additional assessment criteria. The background of the different technologies related to water reuse and the underlying theory are explained. Furthermore, national thematic subjects related to water reuse are included in form of a multi-criteria analysis called PESTLE (political, economic, sociological, technological, legal and environmental). These indicators collectively aim to provide an indicative general understanding of the current situation of water reuse in Egypt, Tunisia, and Morocco and are selected on the basis of existing indicators, which were scanned from major water reuse studies and recognized databases (Esteve et al., 2017; FAO - UN Food

[1] https://www.madforwater.eu, This project has received funding from the European Horizon 2020 WATER-5c-2015 Program for the development of water supply and sanitation technology, systems and tools, and/or methodologies

and Agriculture Organisation, 2016; Snethlage et al., 2018). The analysis was also applied to Australia. The reason for integrating Australia is its function as a benchmark country with well-established water reuse practices (Asian Development Bank, 2017).

Poseidon 2.0 can be applied prior to a more detailed feasibility study in order to assess possible water-reuse options and it shows decision makers and other stakeholders that implementable solutions are available which comply with local requirements, as shown in Figure 2.

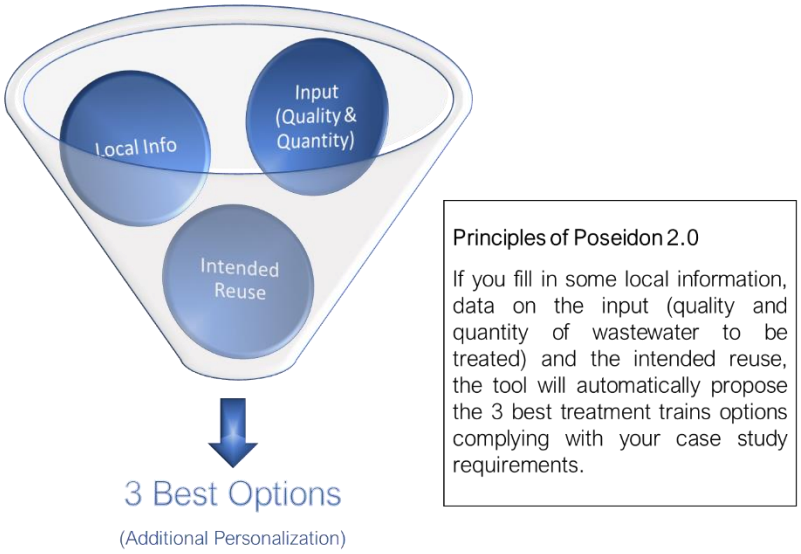
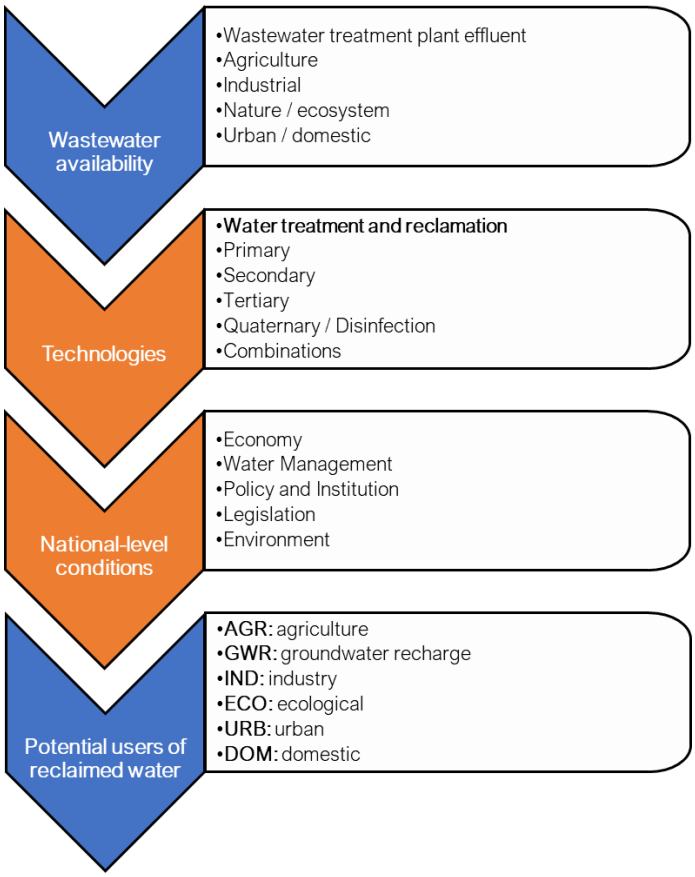


Figure 2: Principle of Poseidon 2.0

3. Basic mode

Typical users: Users not used to this tool and non-experts of wastewater treatment technologies.

Typical use: The typical intended use of this basic mode is to learn about water-reuse treatment technologies and to analyze which treatment trains would comply with your own situation, as shown in Figure 3.



Starting point:
Selected case study sites with potential for Water Reuse & Recycling, data and information

Challenge:
Many possibilities depending on quality requirements and scheme / technology combinations

⇒ **Poseidon 2.0 proposes and compares a basket of options to foster the undertaking of feasibility studies**

Figure 3: Main objectives

The next sections will provide you with all the necessary steps to take in order to reach a basket of three top-ranked options for wastewater treatment.

3.1 Welcome

"*Welcome*" is the first sheet of the Excel-Tool where you can find a first structural timeline overview. There are two fields to be filled out, (a) your country of origin and (b) the currency to be applied for cost purposes.

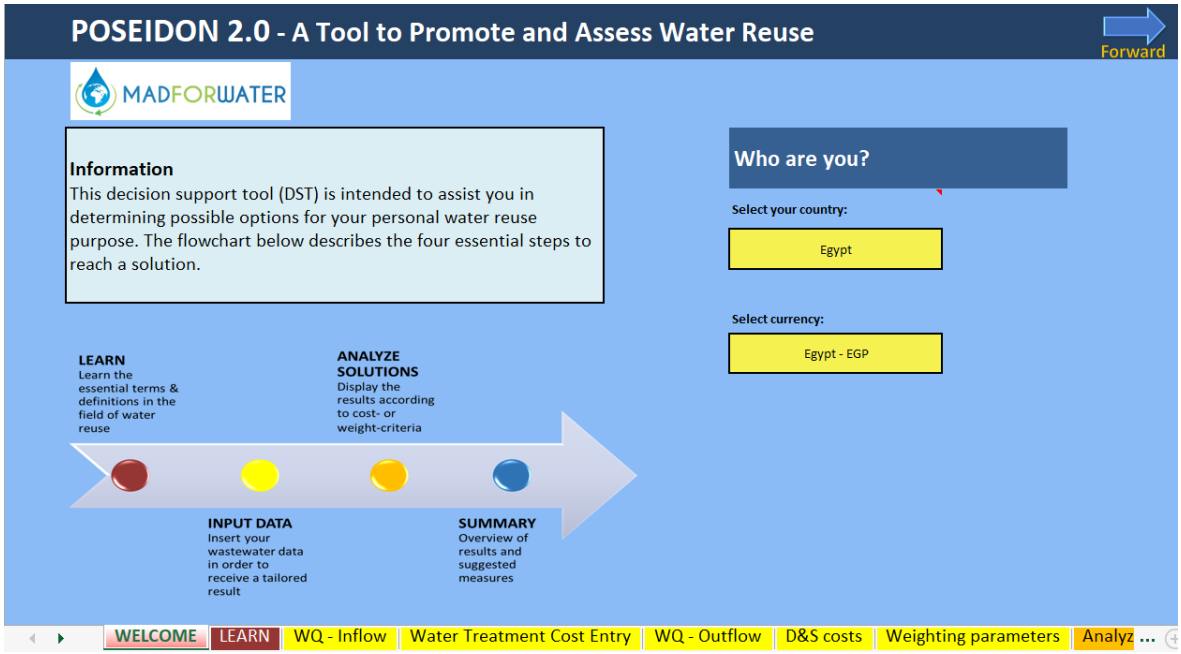


Figure 4: Welcome.

3.2 Learn

Learn about Poseidon 2.0 by using the dropdown list. The essential definitions and terms about wastewater treatment and reuse are provided in this section. You will find a selection of different questions about the tool and some abbreviations you might not be familiar with. By selecting one of the questions, the tool will automatically give you the answer in form of a picture or chart, together with a short description.

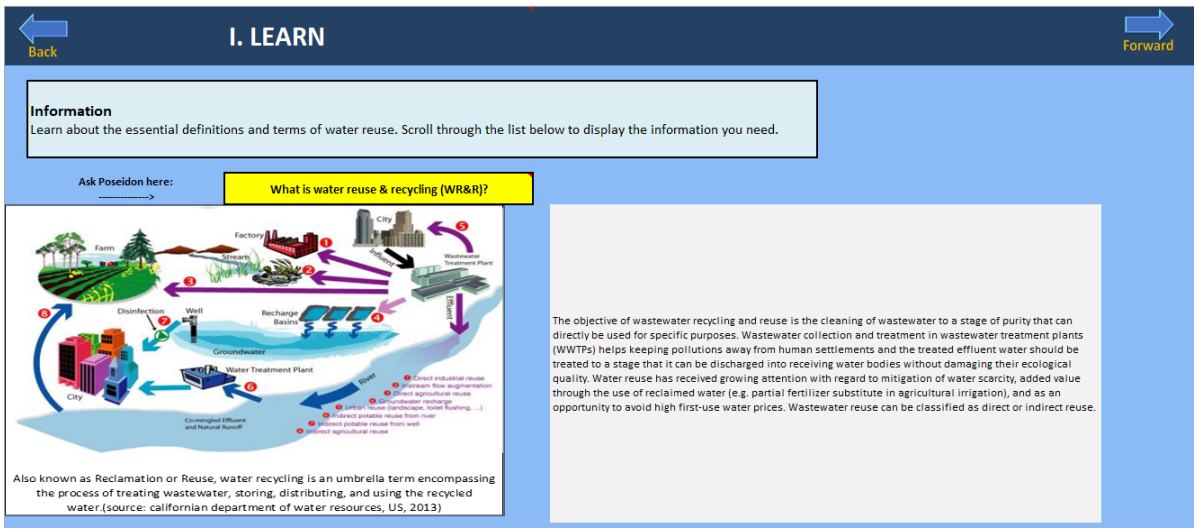


Figure 5: Learn

3.3 Water quality – Inflow

You will find all the details about different water quality classes included in Poseidon 2.0. There is a short description and references as well. Water quality regulations, recommendations and requirements are a very broad topic and sometimes remain undefined. In addition, compliance with requirements is a separate topic. For this reason, the tool proposes a catalogue of quality classes from several references (USEPA, WHO, national regulations, etc.) as an indication, and the user can either select one of those classes or adapt it to its own local conditions by using the dropdown list under point 1. Some references propose a range of values for selected parameters, and this section allows the user to see what is used for the calculation and where those numbers come from, along with some additional information. Furthermore, the quantity of the wastewater inflow has also to be defined under point 2. You can choose between three different units, (a) Peak flow, (b) Average flow, and (c) Serviced population.

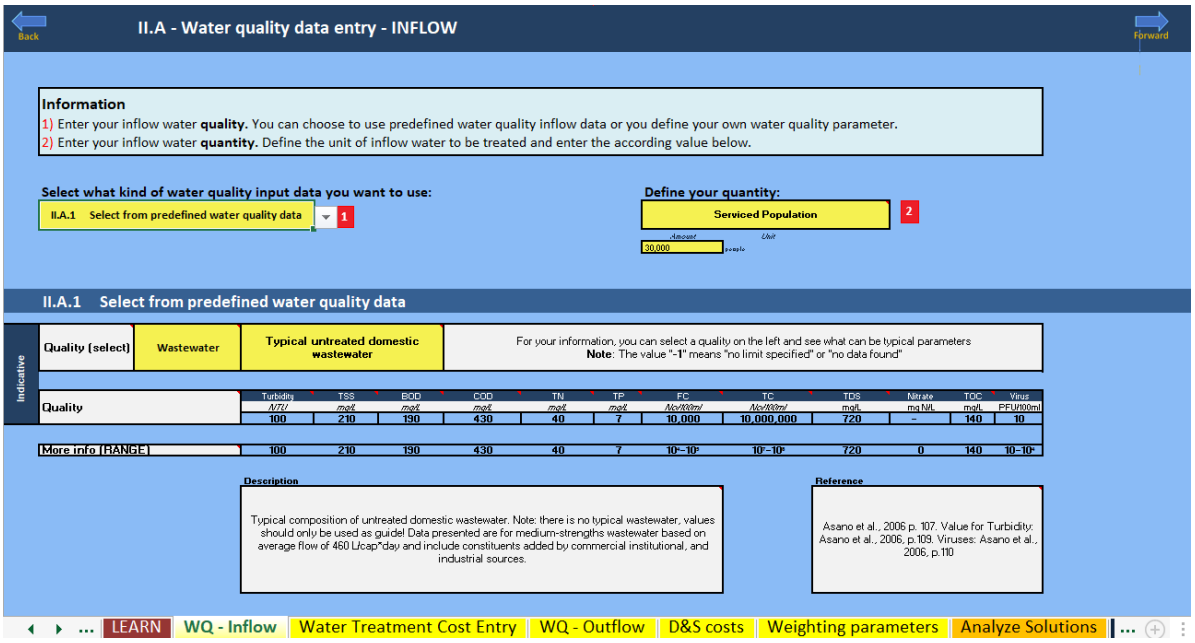


Figure 6: Water quality - Inflow

3.4 Water treatment cost entry

The cost data used were compiled from various sources. These only represent country-specific average values. You are therefore given the opportunity to personalize the costs, since local costs can vary greatly depending on the site. In order to enter personal costs, you must first select "*Your case*" under currency in "*Welcome*". Otherwise the calculation will be based on the average costs.

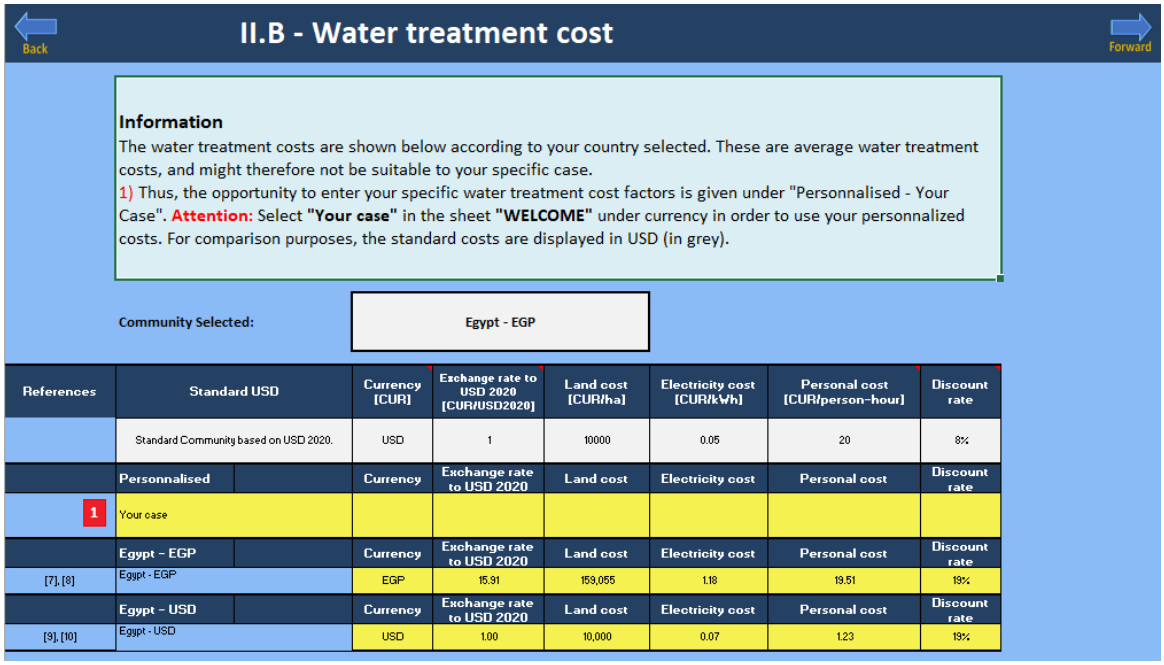


Figure 7: Water treatment cost entry.

3.5 Water quality – Outflow

The Excel-Tool is versatile and can be used for up to three different end-uses. The only required data regarding the water quality outflow are as follows (see Figure 8):

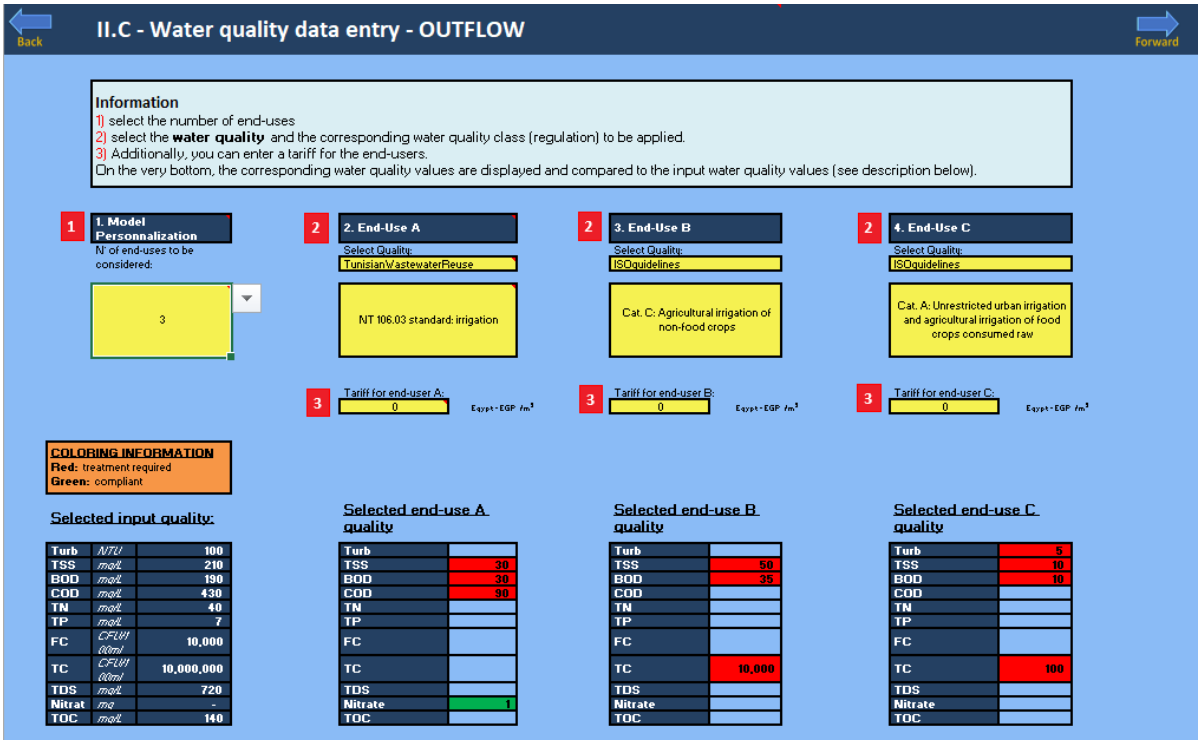


Figure 8: Water quality - Outflow.

1. **Model personalization:** You have the option to personalize the end-use purpose up to three different cases.
2. **End-use quality:** What is the quality requirement for your intended end-use of the water after treatment? You can choose from a list of pre-defined quality categories and specify in a second step the water quality class.
3. **Tariff for end-user:** Specify the price at which the reused water can be sold to the intended end-user.

3.6 Distribution and storage costs

First, define the specific quantity you will deliver to each end-user. Second, specify the length of the pipes required and the elevation to calculate the pumping costs. You can also specify whether you need a water or wastewater storage facility.

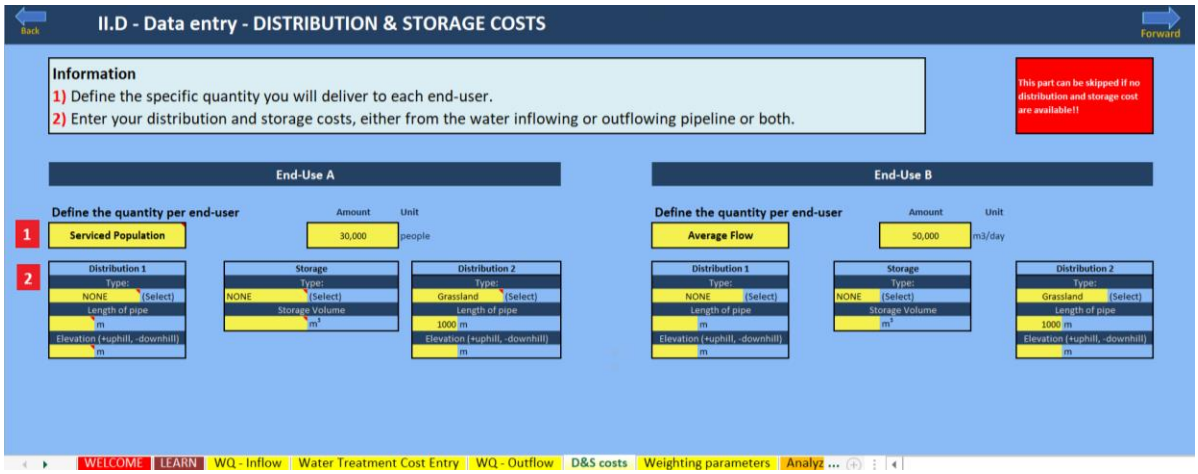


Figure 9: Distribution and storage costs.

Based on the input data in the preceding sections, the Excel-Tool will calculate the performance, cost, and other assessment criteria for all the treatment trains included in the system and propose to you three top-ranked options according to a varied selection and assessment methods as explained in Sections 2.7 and 2.8.

3.7 Calculation and Assessment Algorithm (Informative)

In order to understand the results, the user should have a basic understanding on how the tool performs the calculations before being able to analyze the results (All those calculations are performed automatically, and the user does not see the details while using the tool). Poseidon contains a catalogue of unit processes (technologies) assembled into a catalogue of treatment trains (i.e., a combination a series of technologies). The treatment trains are based on case studies and contain main benchmarks treatment trains and several additional examples worldwide. One example

of treatment train is shown in Figure *10*. Poseidon 2.0 contains around 40 unit processes and around 50 treatment trains.

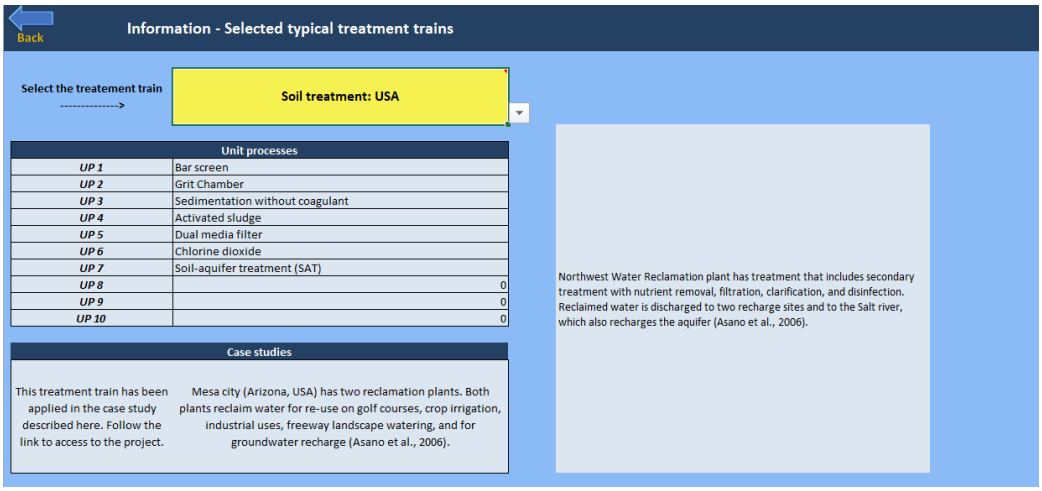


Figure 10: Soil treatment USA: example of a treatment train composed of 7 unit processes.

Each unit process, and therefore each treatment train, contains following information:

1. General description of unit process, treatment trains that can be found in the additional information sheet "L3" of the Excel-Tool (also accessible from the “results” sheets)
2. Pollutant removal percentage for each water quality parameter under minimum, average, and maximum performance
3. Quantitative lifecycle costs information in order to calculate the important cost components for each case
4. Additional assessment criteria for the technical assessment, requirements, impacts, cost, and resources, where the values are between 0 and 3 (0 = nil, 1 = low, 2 = medium and 3 = high)
5. A normalized and aggregated single treatment train score that is calculated based on the weights defined by the user (Figure *11*). The values are between 0 (worst) and 3 (best).

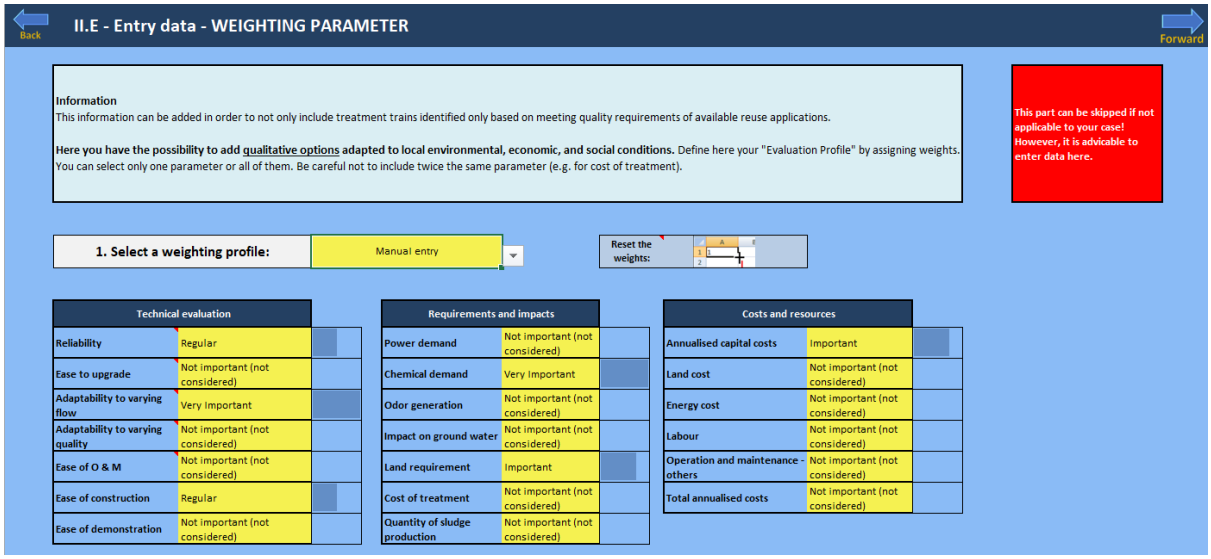


Figure 11: Weight the relative importance of different parameters in order to calculate an overall treatment train score.

3.8 Elimination, Ranking and Assessment Process

As described in the previous section, each parameter is calculated for each treatment train included in Poseidon 2.0. Those parameters can be divided into three categories:

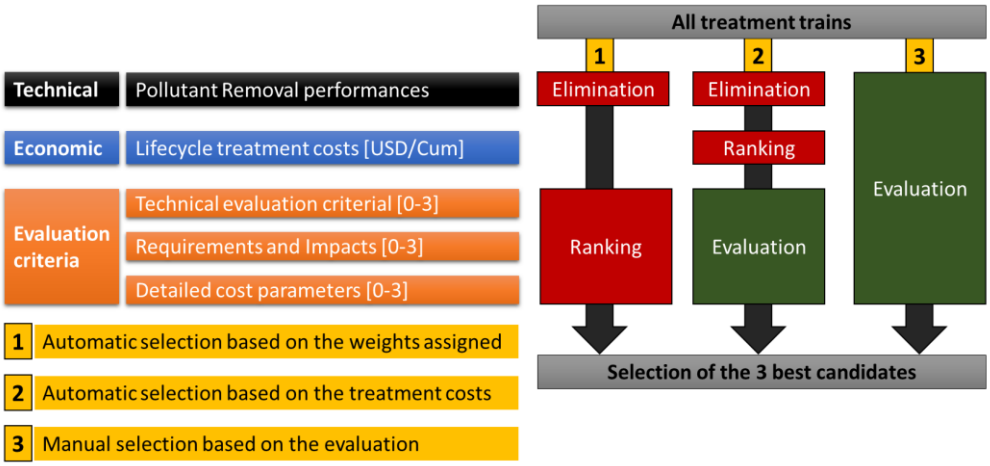


Figure 12: Assessment algorithm proposed by the stage II assessment.

1. **Technical:** This is the calculation of the pollutant-removal performance for the considered quality parameters. If a given treatment train complies with all the water quality parameters specified for a given end-use, the treatment train is considered compliant.[2]

[2] Note that for each parameter, three performances are calculated (minimum, average and maximum performance), depending on the operation conditions and external factors. In the selection process, the maximum performance is considered, and the user should be aware that under less well-operating treatment trains, the quality might not comply with the water quality required for the end-use.

2. Economic: These are the lifecycle treatment costs calculated quantitatively in the selected currency per cubic meter. Such a cost is calculated for each treatment train.
3. Assessment criteria: These are all the additional assessment criteria that are normalized, and their values are between 0 and 3 (0 = nil, 1 = low, 2 = medium, and 3 = high). Out of those assessment criteria, another aggregated score is calculated for every treatment train based on the assigned weights by the user, as explained in the previous section.

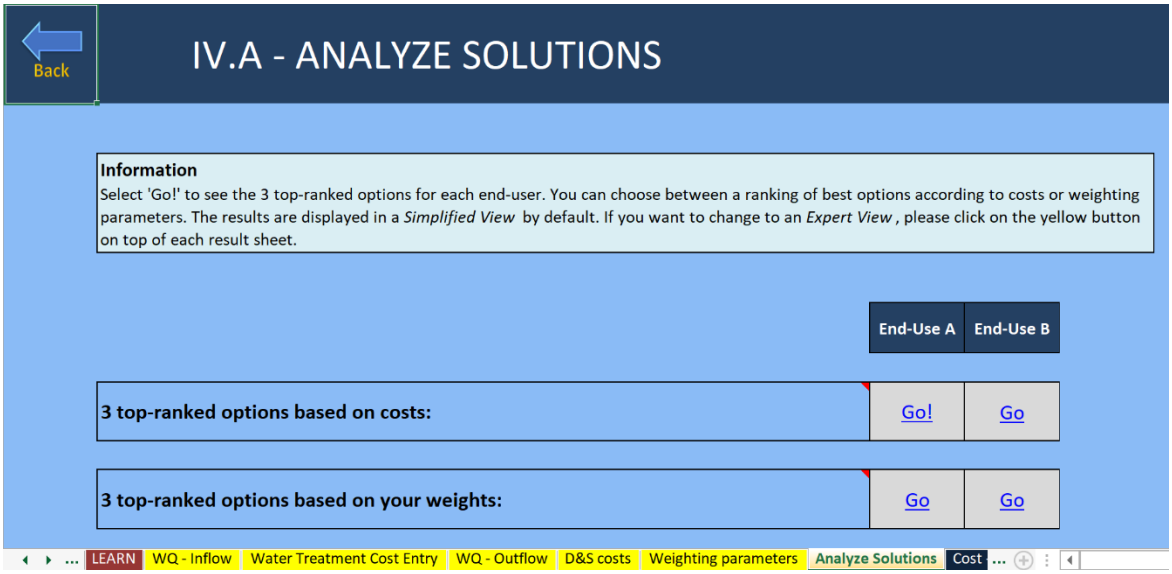


Figure 13: Analyze solutions.

Based on those three categories of parameters (technical, economic, and assessment criteria), the user can proceed to three main elimination, ranking, and assessment selections, as represented in Figure *12* and Figure *13*.

The results are displayed in a simplified view of the PESTLE results by default. The simplified results are designed to give an initial overview of the national-level conditions regarding the various subjects of wastewater treatment. If you want to have a more detailed analysis of the national-level conditions, please select "*Expert Results*" in each result sheet. Next, you can display the results according to the following two criteria:

1. Automatic selection based on the treatment costs: In this mode, all treatment trains not complying with the water quality required are eliminated (under maximum performance). The treatment trains complying with the quality required by the foreseen end-use are ranked according to the lifecycle treatment costs, and the three top-ranked treatment trains are presented. In addition, the assessment criteria are displayed but do not affect the ranking.

2. **Automatic selection based on the weights assigned:** In this mode, all treatment trains not complying with the water quality required are eliminated (under maximum performance). The treatment trains complying with the quality required by the foreseen end-use are ranked according to the aggregated treatment trains' single score, based on the weights assigned by the user. The best three candidates are presented automatically.

3.9 Understanding the Results

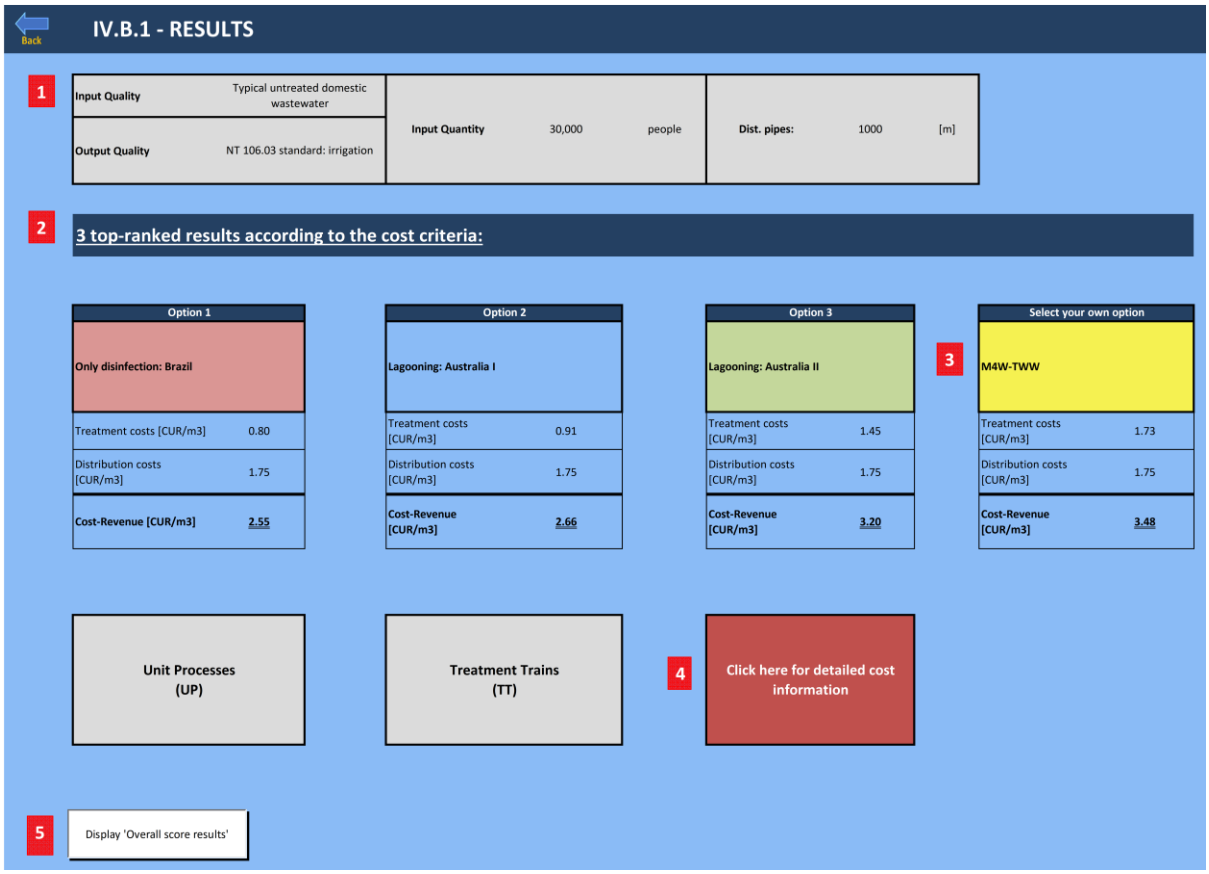
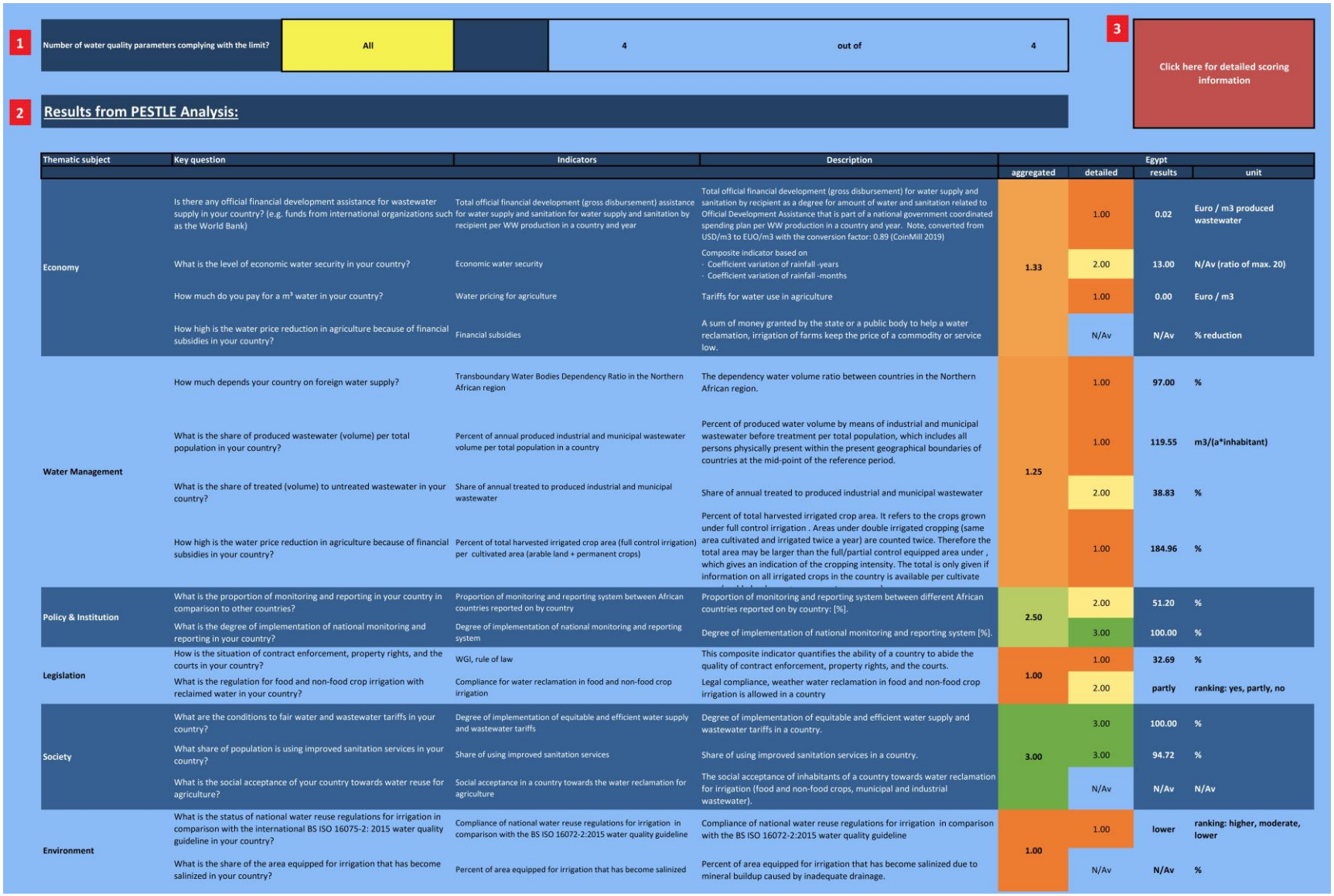


Figure 14: Example 1 of results sheet.

When looking at the results, you can see that the results are divided in two sections, as you can see in **Figure** *14* and **Figure** *15*. The first section on the left side covers the following:

1. The data input is recapitulated (input quality and quantity, output quality, and distribution)
2. The three top-ranked wastewater treatment technology options that comply with your desired outflow quality are displayed in three colors (red, blue, green). For each option, the name of the treatment train is displayed. The additional information on the treatment trains and the process units included can be accessed through the two grey buttons below the three options.

3. If you want to compare the three top-ranked options, you can do this here. Select a treatment train from the dropdown list to see the cost figures attributed to the selected treatment train.
4. In addition, some results are presented in an additional sheet that can be accessed by selecting the red bottom below the three options, as shown in Figure *16*.
5. The overall score results of the three best-ranked options are presented in a table form at the bottom of the sheet. You can access them by selecting the grey button.



1	Number of water quality parameters complying with the limit?	All		4	out of	4

3 Click here for detailed scoring information

2 Results from PESTLE Analysis:

Thematic subject	Key question	Indicators	Description	Egypt			
				aggregated	detailed	results	unit
Economy	Is there any official financial development assistance for wastewater supply in your country? (e.g. funds from international organizations such as the World Bank)	Total official financial development (gross disbursement) assistance for water supply and sanitation for water supply and sanitation by recipient per WW production in a country and year	Total official financial development (gross disbursement) for water supply and sanitation by recipient as a degree for amount of water and sanitation related to Official Development Assistance that is part of a national government coordinated spending plan per WW production in a country and year. Note, converted from USD/m3 to EUO/m3 with the conversion factor: 0.89 (CoinMill 2019)	1.33	1.00	0.02	Euro / m3 produced wastewater
	What is the level of economic water security in your country?	Economic water security	Composite indicator based on · Coefficient variation of rainfall -years · Coefficient variation of rainfall -months		2.00	13.00	N/Av (ratio of max. 20)
	How much do you pay for a m^3 water in your country?	Water pricing for agriculture	Tariffs for water use in agriculture		1.00	0.00	Euro / m3
	How high is the water price reduction in agriculture because of financial subsidies in your country?	Financial subsidies	A sum of money granted by the state or a public body to help a water reclamation, irrigation of farms keep the price of a commodity or service low.		N/Av	N/Av	% reduction
Water Management	How much depends your country on foreign water supply?	Transboundary Water Bodies Dependency Ratio in the Northern African region	The dependency water volume ratio between countries in the Northern African region.	1.25	1.00	97.00	%
	What is the share of produced wastewater (volume) per total population in your country?	Percent of annual produced industrial and municipal wastewater volume per total population in a country	Percent of produced water volume by means of industrial and municipal wastewater before treatment per total population, which includes all persons physically present within the present geographical boundaries of countries at the mid-point of the reference period.		1.00	119.55	m3/(a*inhabitant)
	What is the share of treated (volume) to untreated wastewater in your country?	Share of annual treated to produced industrial and municipal wastewater	Share of annual treated to produced industrial and municipal wastewater		2.00	38.83	%
	How high is the water price reduction in agriculture because of financial subsidies in your country?	Percent of total harvested irrigated crop area (full control irrigation) per cultivated area (arable land + permanent crops)	Percent of total harvested irrigated crop area. It refers to the crops grown under full control irrigation . Areas under double irrigated cropping (same area cultivated and irrigated twice a year) are counted twice. Therefore the total area may be larger than the full/partial control equipped area under , which gives an indication of the cropping intensity. The total is only given if information on all irrigated crops in the country is available per cultivate		1.00	184.96	%
Policy & Institution	What is the proportion of monitoring and reporting in your country in comparison to other countries?	Proportion of monitoring and reporting system between African countries reported on by country	Proportion of monitoring and reporting system between different African countries reported on by country: [%].	2.50	2.00	51.20	%
	What is the degree of implementation of national monitoring and reporting in your country?	Degree of implementation of national monitoring and reporting system	Degree of implementation of national monitoring and reporting system [%].		3.00	100.00	%
Legislation	How is the situation of contract enforcement, property rights, and the courts in your country?	WGI, rule of law	This composite indicator quantifies the ability of a country to abide the quality of contract enforcement, property rights, and the courts.	1.00	1.00	32.69	%
	What is the regulation for food and non-food crop irrigation with reclaimed water in your country?	Compliance for water reclamation in food and non-food crop irrigation	Legal compliance, weather water reclamation in food and non-food crop irrigation is allowed in a country		2.00	partly	ranking: yes, partly, no
Society	What are the conditions to fair water and wastewater tariffs in your country?	Degree of implementation of equitable and efficient water supply and wastewater tariffs	Degree of implementation of equitable and efficient water supply and wastewater tariffs in a country.	3.00	3.00	100.00	%
	What share of population is using improved sanitation services in your country?	Share of using improved sanitation services	Share of using improved sanitation services in a country.		3.00	94.72	%
	What is the social acceptance of your country towards water reuse for agriculture?	Social acceptance in a country towards the water reclamation for agriculture	The social acceptance of inhabitants of a country towards water reclamation for irrigation (food and non-food crops, municipal and industrial wastewater).		N/Av	N/Av	N/Av
Environment	What is the status of national water reuse regulations for irrigation in comparison with the international BS ISO 16075-2: 2015 water quality guideline in your country?	Compliance of national water reuse regulations for irrigation in comparison with the BS ISO 16072-2:2015 water quality guideline	Compliance of national water reuse regulations for irrigation in comparison with the BS ISO 16072-2:2015 water quality guideline	1.00	1.00	lower	ranking: higher, moderate, lower
	What is the share of the area equipped for irrigation that has become salinized in your country?	Percent of area equipped for irrigation that has become salinized	Percent of area equipped for irrigation that has become salinized due to mineral buildup caused by inadequate drainage.		N/Av	N/Av	%

Figure 15: Example 2 of results sheet.

The second section on the right side covers the PESTLE result. The following results are displayed:

1. This still belongs to the first section explained above. In case no treatment train complies with the water quality required, you can choose how many water quality parameters should comply with the requirements (e.g. two out of three).
2. Here you see results from the PESTLE analysis (political, economic, social, water management, legislation, and environment) that covered national thematic subjects related to water reuse. On the left side you see the thematic subjects, followed by key questions. These are underpinned by (semi-)quantitative indicators. On the very right side you see the results, which were normalized to a scoring between 1 (orange; lower ranked), 2 (yellow; moderate ranked), and 3 (green; higher ranked). The detailed results were aggregated to provide an overall statement of each thematic subject. If you want to know more about the methodology used to derive these results, please see the MADFORWATER project report D5.2.
3. This button takes you to the detailed calculations of the PESTLE analysis.

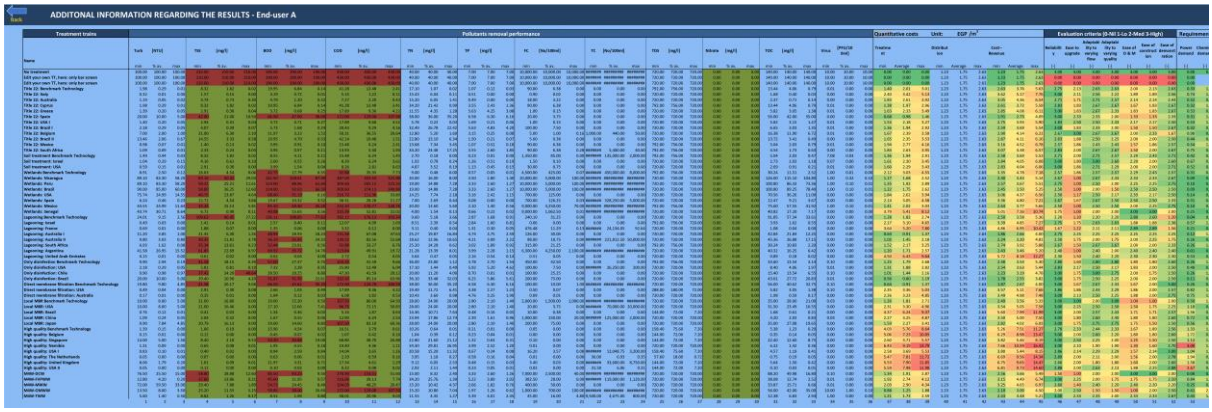


Figure 16: Results for all treatment trains displayed in a table.

3.10 Summary

The very last sheet of the Excel-Tool figures as a summary of all scenarios considered, including the treatment trains suggested, the costs attributed to the proposed treatment trains, and suggested measures according to the PESTLE analysis.

Figure 17: Summary of all scenarios considered.

This last sheets purpose is to give a short and concise overview of all cases analyzed. Firstly, the user should select one out of the three proposed top-ranked options (cost and weighted results). By making a selection, the user is simultaneously shown the associated costs under the second section “Costs in CUR/m3”. Furthermore, the user is shown the water tariffs paid for treated wastewater in the selected country. This provides the user with an overview of the costs and revenues. Finally, the user is shown possible measuers based on the PESTLE analysis. The color coding of the analysis is used. Meaning that in those categories that are colored red or orange, it is more likely that action is needed.

4. Typical Example – Two Potential Water Reuse Scenarios for Untreated Wastewater from a City

A village in Egypt with typical domestic untreated wastewater from 30,000 inhabitants is considered. You would like to analyze how to treat this water for two scenarios and find the 3 top-ranked options based on costs of treatment as described in Figure *18*.

Scenario 1: Reuse for aquaculture.

Scenario 2: Reuse for landscape irrigation in urban areas according to Egyptian wastewater reuse regulations

The foreseen wastewater treatment plant (WWTP) will be at an altitude of 1,000 m above sea level. The foreseen agriculture area is 1 km away in a rural area and has an altitude of 500 m above sea level. The landscape area is 100 m away from the foreseen WWTP.

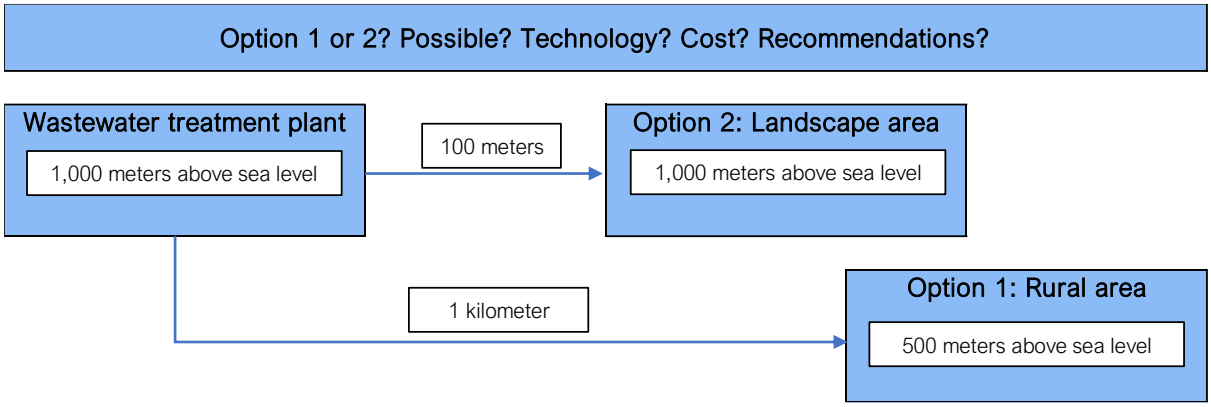


Figure 18: Visualization of example task.

Answer the following questions:

- Are there suitable treatment trains for reuses 1 or 2, or both?
- Which are the best three options based on the costs?
- What are the costs of treatment for those options?
- What are the costs of distribution?
- What are possible measures to tackle national-level barriers?

4.1 Suggested Procedure

Figure *19* shows how the tool looks at the beginning of an assessment.

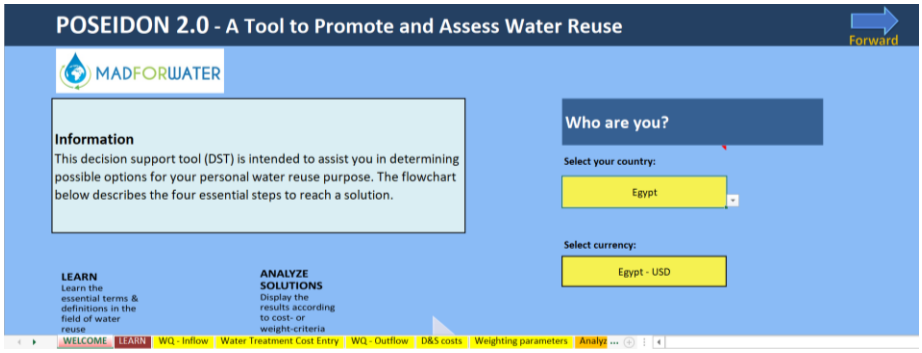


Figure 19: Starting point.

First select your country of origin *"Egypt"* and the currency you want to apply, in this case *"Egypt – USD"*.

Let's start to fill in information

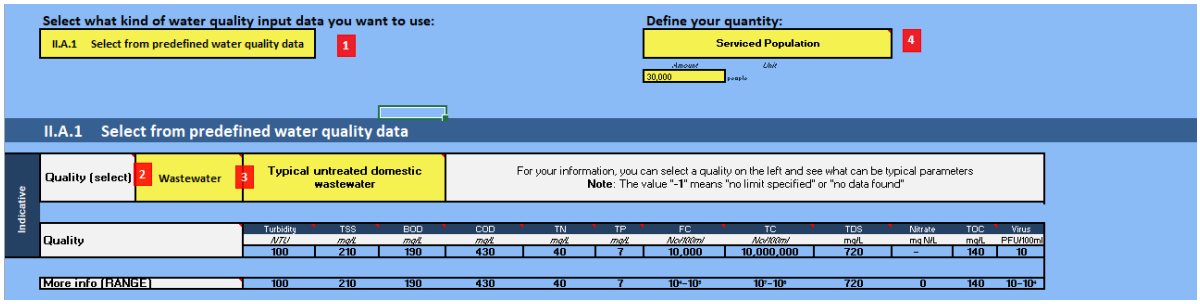


Figure 20: Water quality and quantity input.

1. First, select "II.A.1 Select from predefined water quality data".
2. Select "Wastewater" from the water categories available.
3. Select "Typical untreated domestic wastewater" from the water quality classes available.
4. Select "Serviced Population" as the unit for the water quantity inflow, and subsequently enter "30,000" in the yellow field below.

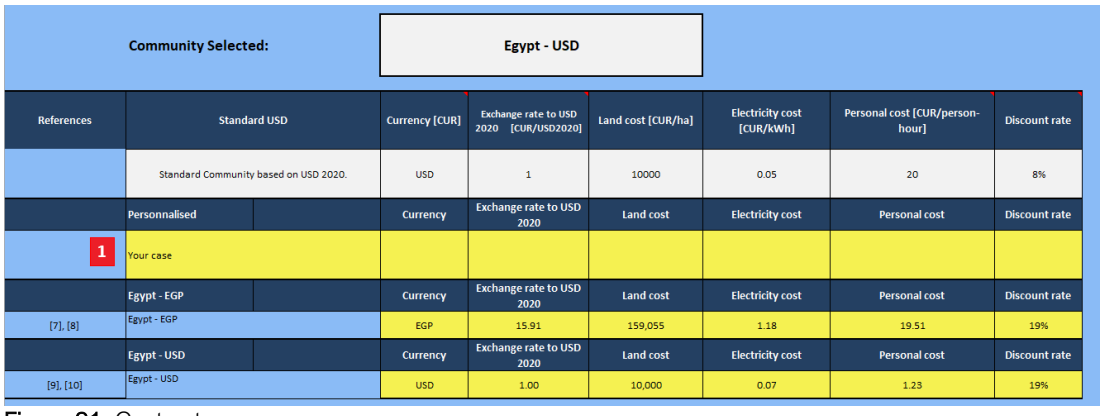


Figure 21: Cost entry.

The average costs proposed by the Excel-Tool can be accepted (as done in this example) or otherwise can be adapted under “Your Case”. However, if you want to adapt the costs, you have to go back to the very first sheet to change the selected currency in Figure *19* to “Your Case”.

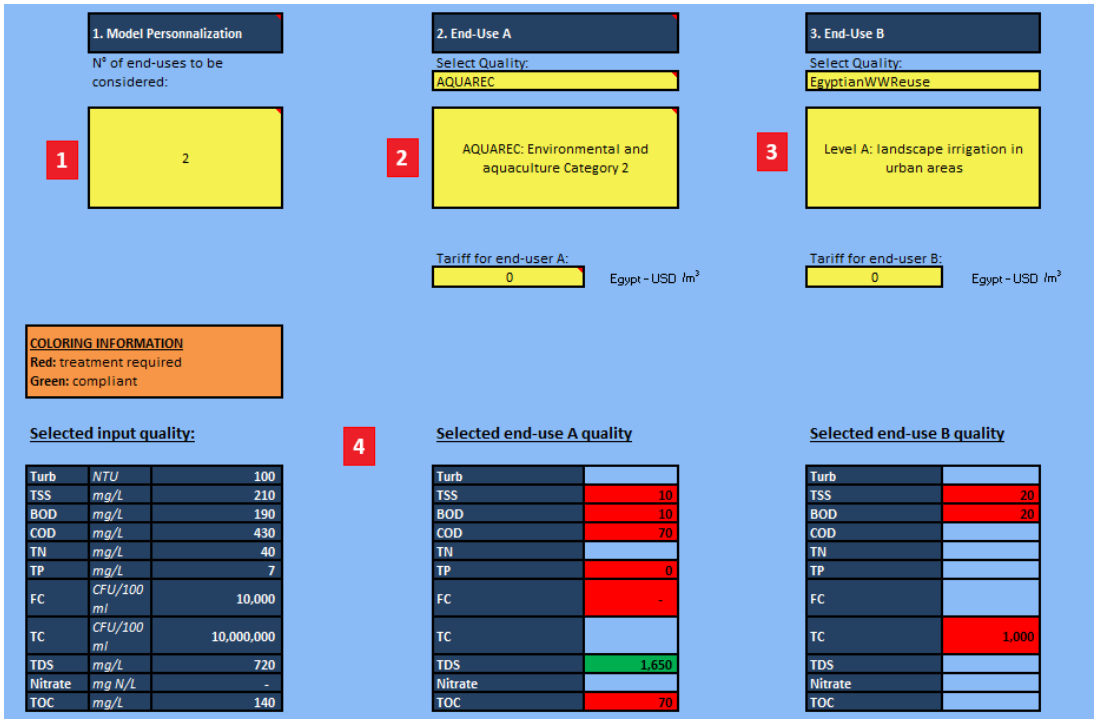


Figure 22: Water quality outflow entry.

1. In N° of end-uses to be considered, enter a value of “2”, because we have 2 different scenarios in this task.
2. Here, choose “AQUAREC” on the top, and just below, choose “AQUAREC: Environmental and aquaculture Category 2”. Since we do not consider an end-user tariff, you can leave this value at 0.
3. Here, choose “EgyptianWWReuse” on the top, and just below, choose “Level A: landscape irrigation in urban areas”. Since we do not consider an end-user tariff, you can leave this value at 0.
4. This is only an informative part of this sheet. It shows if the water inflow quality parameters are already complying with the desired water outflow qualities without any treatment. If all parameter values would be colored green, no additional treatment would be necessary.

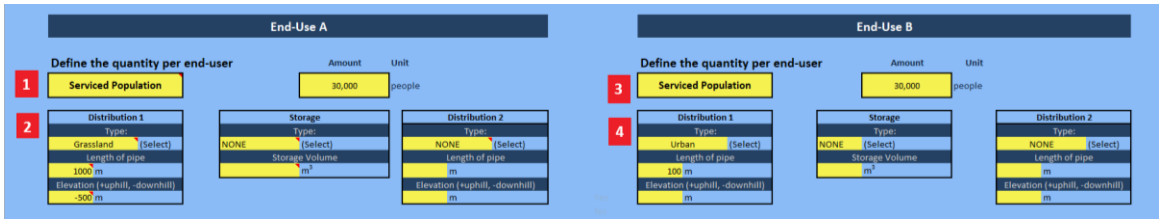


Figure 23: Distribution and storage cost entry.

1. Here you can further specify the water outflow quantity per end-user. We assume that the landscape area and the rural area are equally receiving the water from the WWTP. Therefore, the "Serviced Population" has not to be changed.
2. Here you enter the distribution distances. Since the treated wastewater will not be stored anywhere, we only need to enter the distance data in the "Distribution 1" section. Select "Grassland" as the type of land and enter "1,000" right below as the length of pipe. Finally, you enter "-500" as the elevation.
3. This is the same as under point 1.
4. Here you choose "Urban" as the type of land and "100" as the length of pipe.

We skip the "Weighting parameters" part in this example because we only consider the three top-ranked options according to cost. However, if you also want to consider the three top-ranked options according to the weighting parameters, please consider entering your preferences in this sheet.

4.2 Suggested Procedure – Analyze the Results

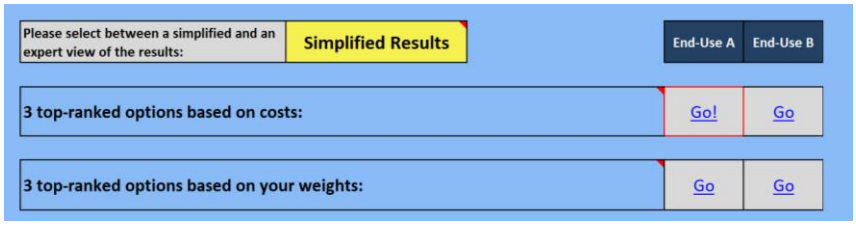


Figure 24: Analyze solutions.

After you entered all necessary input data, you can now select one of the two buttons under "3 top-ranked options based on costs". For example, if you click the leftmost "Go!" (see **Figure *24***), you will see the three top-ranked options based on costs for the 1st scenario. If you click the "Go!" on the right side, you will see the same, but adapted to the 2nd scenario.

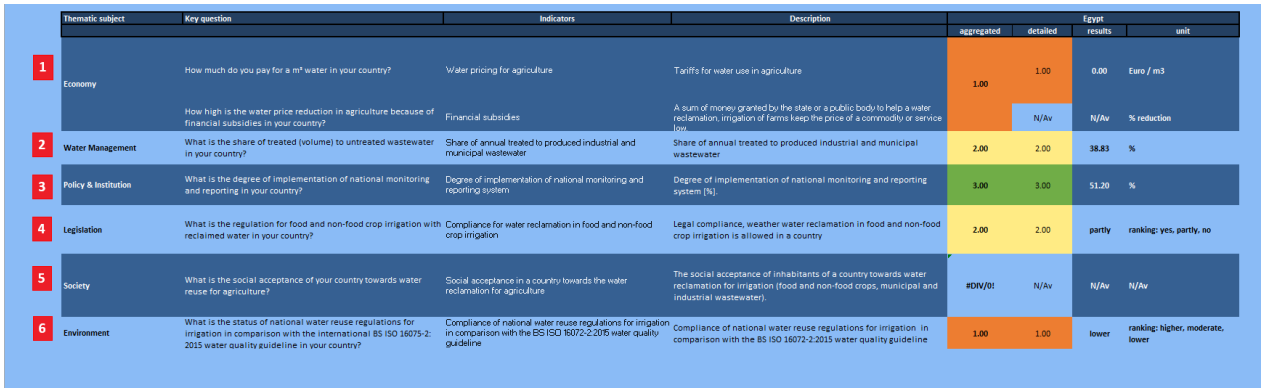
1	Input Quality	Typical untreated domestic wastewater	Input Quantity	30,000	people	Dist. pipes: 1000 [m]
	Output Quality	AQUAREC: Environmental and aquaculture Category 2				

2 3 top-ranked results according to the cost criteria:

	Option 1	Option 2	Option 3	3 Select your own option
	Soil treatment: Israel	Title 22: USA I	Title 22: Brazil II	M4W-TWW
Treatment costs [CUR/m3]	1.36	1.43	1.48	1.11
Distribution costs [CUR/m3]	0.01	0.01	0.01	0.01
Cost-Revenue [CUR/m3]	1.38	1.45	1.50	1.13

Figure 25: Table with results.

1. Here you can see the input data for the 1st scenario.
2. The three top-ranked options are displayed here. These are examples of projects in other countries which are already in service. The associated costs are shown below the options. The cost-revenue is calculated based on the entered costs and the foreseeable tariff. Since we have not specified any end-use tariff, the cost-revenue is only the rounded sum of the treatment and distribution costs.
3. Here you can select any other treatment train available in this Excel-Tool. This serves as a comparison option.



	Thematic subject	Key question	Indicators	Description	Egypt aggregated	Egypt detailed	Egypt results	Egypt unit
1	Economy	How much do you pay for a m³ water in your country?	Water pricing for agriculture	Tariffs for water use in agriculture	1.00	1.00	0.00	Euro / m3
		How high is the water price reduction in agriculture because of financial subsidies in your country?	Financial subsidies	A sum of money granted by the state or a public body to help a water reclamation, irrigation of farms keep the price of a commodity or service low.		N/Av	N/Av	% reduction
2	Water Management	What is the share of treated (volume) to untreated wastewater in your country?	Share of annual treated to produced industrial and municipal wastewater	Share of annual treated to produced industrial and municipal wastewater	2.00	2.00	38.83	%
3	Policy & Institution	What is the degree of implementation of national monitoring and reporting in your country?	Degree of implementation of national monitoring and reporting system	Degree of implementation of national monitoring and reporting system [%].	3.00	3.00	51.20	%
4	Legislation	What is the regulation for food and non-food crop irrigation with reclaimed water in your country?	Compliance for water reclamation in food and non-food crop irrigation	Legal compliance, weather water reclamation in food and non-food crop irrigation is allowed in a country	2.00	2.00	partly	ranking: yes, partly, no
5	Society	What is the social acceptance of your country towards water reuse for agriculture?	Social acceptance in a country towards the water reclamation for agriculture	The social acceptance of inhabitants of a country towards water reclamation for irrigation (food and non-food crops, municipal and industrial wastewater).	#DIV/0!	N/Av	N/Av	N/Av
6	Environment	What is the status of national water reuse regulations for irrigation in comparison with the international BS ISO 16075-2: 2015 water quality guideline in your country?	Compliance of national water reuse regulations for irrigation in comparison with the BS ISO 16072-2:2015 water quality guideline	Compliance of national water reuse regulations for irrigation in comparison with the BS ISO 16072-2:2015 water quality guideline	1.00	1.00	lower	ranking: higher, moderate, lower

Figure 26: PESTLE analysis simplified results.

We selected the *"simplified results"* for the PESTLE analysis in order to have a concise overview of the national-level conditions.

1. The economic results indicate rather low water tariffs to be paid for the water use in agriculture. It can therefore be concluded that as a WWTP no direct income can be generated from treated wastewater sale. However, it should be noted that at the time of the PESTLE analysis no data were available on the subsidies paid. It

can be assumed, that this is the case in Egypt and that the WWTP therefore does generate indirect revenue through subsidies.

2. The water management results indicate a moderate share of treated to untreated wastewater volume in Egypt (around 39%). Consequently, an entry into the wastewater treatment market still seems worthwhile from this perspective, as there is no market saturation yet.
3. The policy and institution results indicate a high degree of national monitoring and reporting implementation. Consequently, as a WWTP operator it can be assumed that the required quality can and must be maintained.
4. The legislation results indicate a partial compliance for water reclamation in food and non-food crop irrigation. Meaning that the irrigation of food and non-food crop with reclaimed water might be allowed in certain circumstances and in others not.
5. The social results could apparently not be measured at the time of the PESTLE analysis. Consequently, no statement can be made on the social acceptance of the use of treated wastewater in agriculture.
6. The environmental results indicate a lower compliance of national water reuse regulations for irrigation in comparison with the BS ISO 16072-2:2015 water quality guideline. This means that there is still room for improvement in terms of the environment. In concrete terms, this means that potentially stricter regulations would have to be introduced to protect the environment more effectively.

4.3 Questions & Answers

1. Are there suitable treatment trains for reuses 1 and/or 2?	Yes, there are a lot of suitable treatments for reuses for both the scenarios.
2. Which are the three top-ranked options based on the costs?	1st scenario (reuse for aquaculture) **Option 1:** Soil treatment: Israel **Option 2:** Title 22: USA I **Option 3:** Title 22: Brazil II 2nd scenario (reuse for landscape irrigation in urban areas) **Option 1:** Lagooning: Australia I **Option 2:** Wetlands: USA **Option 3:** Title 22: Belgium

3. What are the costs of treatment for those options?	1st scenario	
	Soil treatment: Israel	1.36 [USD/m^3]
	Title 22: USA I	1.43 [USD/m^3]
	Title 22: Brazil II	1.48 [USD/m^3]
	2nd scenario	
	Lagooning: Australia I	0.47 [USD/m^3]
	Wetlands: USA	0.97 [USD/m^3]
	Title 22: Belgium	1.16 [USD/m^3]
4. What are the costs of distribution?	**1st scenario:**	0.01 [USD/m^3]
	2nd scenario:	0.01 [USD/m^3]

Remarks and analysis: For this case, it appears that it is necessary to treat the wastewater separately in order to comply with the water quality requirements. Consequently, it is likely that only one strategy will be followed. This Excel-Tool therefore gives a first impression on the feasibility of these two scenarios in combination. This conclusion can now be used to re-evaluate the foreseen water reuse. For example, further scenarios can be evaluated with the Excel-Tool, which might have more similar reuse purposes. Furthermore, from the a WWTP operator perspective, it might be advisable to keep an eye on the economic and environmental results of the PESTLE analysis, as these two thematic subjects are most likely to require measures.

5. Conclusions

Poseidon 2.0 is a tool to promote and asses water reuse. Different parameters can be personalized and adapted in this tool per user. The values calculated by Poseidon 2.0 should not be considered absolute values but only as indicators. The accuracy is not guaranteed. The given results show different possibilities to adapt or enhance the treatment of wastewater, but only the implementation in “real life” with adapted monitoring of the treatment can produce accurate values for a given treatment plant.

6. Glossary

Term	Definition *(applied to the use and understanding of Poseidon 2.0)*
Input	The wastewater that has to be treated before being reused
Unit Processes	Single water treatment technologies (primary, secondary, tertiary treatment and disinfection technologies)
Treatment Trains	Series of unit processes combined in a so-called treatment train or treatment chain
End-use	The intended reuse of reclaimed water after its treatment with an adequate treatment train (e.g. agricultural, industrial, potable reuse or environmental recharge)
Quality class	Defined by several quality parameters included in the tool (e.g. turbidity, biological oxygen demand, etc.); those included in Poseidon 2.0 either represent typical water quality of wastewaters or limits based on guidelines and recommendations for reuse
Weighting	Can be assigned to the different assessment criteria in order to calculate an overall treatment train score (single indicator) that consider the relative importance of different criteria based on specific cases
Distribution	Transport of wastewater and water in pipes or open channels; depending on elevation, distribution involves pumping
Wastewater	Water which has been polluted by human activities
Water reuse	Beneficial use of reclaimed water
Greywater	Wastewater from households or office buildings (bathing, cleaning, laundry, etc.) without faecal contamination, i.e. all streams except for the wastewater from toilets
Blackwater	Wastewater and sewage from toilets
Primary treatment	Usually first step in cleaning process involving removal of solids, oils, and greases by flotation, sedimentation, and screening

Term	Definition *(applied to the use and understanding of Poseidon 2.0)*
Secondary treatment	Removal of dissolved suspended biological matter, which typically involves biological processes by microorganisms (activated sludge, membrane bioreactors, etc.)
Tertiary treatment	Cleaning to a high level of purity or removal of specific contaminants (e.g. heavy metals); can include disinfection
Water reclamation	Cleaning of wastewater to a purity that can be used for specific purposes
Direct reuse	Direct use of reclaimed water for a specific purpose
Indirect reuse	Reuse of wastewater which has been previously mixed and diluted with fresh water by discharge into receiving water bodies

7. References

Asian Development Bank. (2017). *Asian Water Development Outlook 2016*. Manali, Philippines: Asian Development Bank. https://doi.org/10.1080/07900620701760556

Esteve, P., Varela-Ortega, C., Martínez Ríos, M., Gafrej, R., Atef, J., Abdel-Motaleb, A. A., … Karajeh, F. (2017). *D1.1. Report on needs and priorities in the field of international cooperation agreements on water management in the target MACs*.

FAO - UN Food and Agriculture Organisation. (2016). AQUASTAT Database. Global Information System on Water and Agriculture.

Snethlage, J., de Miguel, A., Daniels, Emma Froebrich, Jochen Gafrej, R., Arous, F., Ouzari, I., & Jaouani, A. (2018). *Water stress and Water Vulnerability indicators and maps*. Netherland.

MADFORWATER. (2020). *WW management strategies and water & land management strategies in agriculture*, Deliverable N. 5.2.