WP54: TRUST DSS Memo

Mark Morley, Kourosh Behzadian, Zoran Kapelan (UNEXE)

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1. Introduction

This document is written for the benefit of internal TRUST reviewers with the aim to help them install and assess the DSS software tool (Deliverable D54.2). A more comprehensive description of the DSS methodology, software tool and demonstration on a real-life example will be provided in the final report (Deliverable 54.3) which is due by the end of the project.

2. DSS Overview

A decision support system (DSS) tool for the strategic planning of an integrated urban water system (UWS) over a pre-defined long-term planning horizon is presented here. The DSS evaluates and ranks a number of user defined alternative intervention strategies (IS or simply alternatives) by evaluating their impact on a number of (user defined) UWS performance indicators (PI), all for a number of (user defined) scenarios.

The four principal steps in using the DSS are as follows:

1. Problem definition
2. Population of Decision matrices (or impact assessment)
3. Ranking of alternatives and viewing detailed results
4. Modification and re-evaluation of Intervention Strategies

The first step (problem definition) is used by the user to specify: (1) scenarios of analyses (e.g. different population growth, climate change and other scenarios defining external conditions in which UWS operates); (2) UWS performance metrics/indicators (PI) that will be used to assess UWS performance under different alternatives; (3) definition of intervention strategies (i.e. alternatives) from a predefined list of intervention options supported by the WaterMet^2 tool. User specific PIs and ISs are allowed too. Scenarios and PIs quantified by WaterMet^2 can be specified by the user from the two separate lists available in the DSS while the user defined PIs need to be quantified by the user using external tools feeding into the DSS or otherwise.

The second step in using the DSS involves: (a) running the WaterMet^2 simulation tool to populate the decision matrices with relevant values, i.e. to calculate, for each scenario analysed, the impact of each intervention strategy (i.e. alternative) on each UWS performance metric specified and (b) manually entering the relevant decision matrix values for each user defined IS and PI ;

Third step requires the user to specify preferences (i.e. weights) for different criteria, i.e. UWS performance PIs and then ranks the intervention strategies by using a Multi Criteria Decision Analysis (MCDA) method. At this point the user can request to view detailed results coming out of WaterMet^2 simulations, all for different alternatives, PIs and scenarios.

The final, fourth step, allows the user to add new or modify existing settings (including ISs, PIs and/or scenarios) and re-calculate the ranks of alternative until the best solution is identified.

The DSS software tool is demonstrated below on northern European real-life case study outlined below. Next, the required steps for populating and running the aforementioned process in the DSS will be described.

3. Real life Case Study

The case study shown here is inspired by, although not completely representative of, the UWS of a northern European city (Fig. 1). This UWS is used here as a reference city for the case study combined with assumptions when necessary.
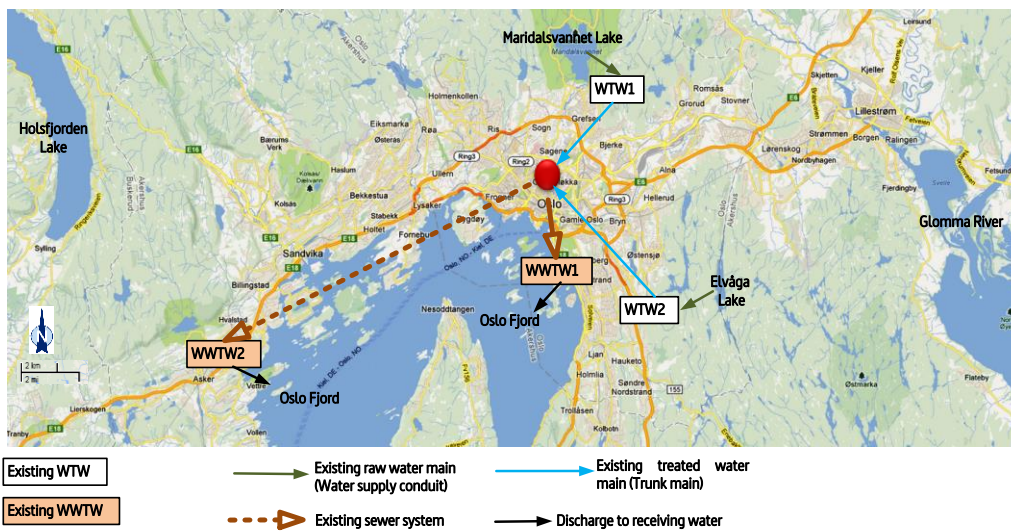

Fig. 1 Layout of the main components in the UWS for existing conditions (Behzadian et al. 2014)

The UWS is likely to face the challenge of population growth in the future which imposes increased water demand on the UWS. Two rates of future population growth (i.e. low and high) can be envisaged for a 30 year planning period starting from 2010. The time series of annual factors for these two rates of population growth and associated water demands in the UWS over the planning horizon are given in Tables 1 and 2.

To address the above issues, three types of intervention options are proposed for this strategic planning as follows:

(1) Addition of a new water resource along with two water treatment works (WTW);
(2) Increased annual rehabilitation rate for pipes;

2

(3) Addition of rainwater harvesting (RWH) and grey water recycling (GWR) schemes;

Based on the above individual intervention options, the following seven UWS intervention strategies (alternatives) against the 30 year planning horizon (2011-2040) are proposed:

(1) Business as usual (BAU);
(2) Addition of a new water resource along with two WTWs starting from 2020;
(3) 1% additional annual pipe rehabilitation starting from 2015;
(4) Addition of RWH and GWR systems at a local level by 25% of households starting from 2015;
(5) Addition of RWH and GWR systems at a local level by 25% and 50% of households, respectively, starting from 2015;
(6) Addition of RWH and GWR systems at a local level by 50% of households starting from 2015;
(7) Addition of RWH and GWR systems at a local level by 25% of households and 0.5% additional rehabilitation annually starting from 2015;

The first strategy assumes business as usual (BAU), i.e. effectively 'do nothing' in the UWS over the planning horizon 2011-2040. In fact, the BAU assumes there is no intervention options are added to the UWS over the planning horizon when the specific rate of population growth (high or low) is envisaged. Therefore, the performance of the other six intervention strategies (# 2-7) comprised of at least one intervention option are compared to each other plus the first strategy. Note that the intervention strategies numbered 3 to 7 start from 2015 while strategy 2 starts from 2020. Applying each of these intervention strategies is expected to have some specific impacts on the performance metrics of the UWS. These performance metrics specified for this analysis are described in the following.

Table 1. Time series of annual factors for low rate of population growth and associated two water demands in the UWS

Scenario variables	Annual population growth factor	Annual industrial water demand growth factor	Annual irrigation water demand growth factor
Units	-	-	-
Year 2011	1.0000	1.0000	1.0000
Year 2012	1.0121	1.0121	1.0121
Year 2013	1.0119	1.0119	1.0119
Year 2014	1.0118	1.0118	1.0118
Year 2015	1.0117	1.0117	1.0117
Year 2016	1.0115	1.0115	1.0115
Year 2017	1.0114	1.0114	1.0114
Year 2018	1.0113	1.0113	1.0113
Year 2019	1.0111	1.0111	1.0111
Year 2020	1.0110	1.0110	1.0110
Year 2021	1.0109	1.0109	1.0109
Year 2022	1.0108	1.0108	1.0108
Year 2023	1.0107	1.0107	1.0107
Year 2024	1.0106	1.0106	1.0106
Year 2025	1.0104	1.0104	1.0104
Year 2026	1.0103	1.0103	1.0103
Year 2027	1.0102	1.0102	1.0102
Year 2028	1.0101	1.0101	1.0101
Year 2029	1.0100	1.0100	1.0100

Scenario variables	Annual population growth factor	Annual industrial water demand growth factor	Annual irrigation water demand growth factor
Year 2030	1.0099	1.0099	1.0099
Year 2031	1.0013	1.0013	1.0013
Year 2032	1.0013	1.0013	1.0013
Year 2033	1.0013	1.0013	1.0013
Year 2034	1.0013	1.0013	1.0013
Year 2035	1.0013	1.0013	1.0013
Year 2036	1.0013	1.0013	1.0013
Year 2037	1.0013	1.0013	1.0013
Year 2038	1.0013	1.0013	1.0013
Year 2039	1.0013	1.0013	1.0013
Year 2040	1.0013	1.0013	1.0013

Table 2. Time series of annual factors for high rate of population growth and associated two water demands in the UWS

Scenario variables	Annual population growth	Annual industrial water demand growth	Annual irrigation water demand growth
Units	-	-	-
Year 2011	1.0000	1.0000	1.0000
Year 2012	1.0240	1.0240	1.0240
Year 2013	1.0230	1.0230	1.0230
Year 2014	1.0230	1.0230	1.0230
Year 2015	1.0220	1.0220	1.0220
Year 2016	1.0220	1.0220	1.0220
Year 2017	1.0210	1.0210	1.0210
Year 2018	1.0210	1.0210	1.0210
Year 2019	1.0200	1.0200	1.0200
Year 2020	1.0200	1.0200	1.0200
Year 2021	1.0200	1.0200	1.0200
Year 2022	1.0190	1.0190	1.0190
Year 2023	1.0190	1.0190	1.0190
Year 2024	1.0180	1.0180	1.0180
Year 2025	1.0180	1.0180	1.0180
Year 2026	1.0180	1.0180	1.0180
Year 2027	1.0170	1.0170	1.0170
Year 2028	1.0170	1.0170	1.0170
Year 2029	1.0170	1.0170	1.0170
Year 2030	1.0170	1.0170	1.0170
Year 2031	1.0140	1.0140	1.0140
Year 2032	1.0140	1.0140	1.0140
Year 2033	1.0130	1.0130	1.0130
Year 2034	1.0130	1.0130	1.0130
Year 2035	1.0130	1.0130	1.0130
Year 2036	1.0130	1.0130	1.0130
Year 2037	1.0130	1.0130	1.0130
Year 2038	1.0130	1.0130	1.0130
Year 2039	1.0120	1.0120	1.0120
Year 2040	1.0120	1.0120	1.0120

According to the performance criteria of sustainability dimensions of water systems (Alegre *et al.*, 2012), six performance metrics are considered for this analysis. These metrics include five quantitative criteria (C_1-C_5), and a single qualitative criterion. A brief description of these metrics is outlined below:

(1) Reliability of water supply (C_1): the ratio of water delivered to customers to the total water demand.

(2) Total cost (C_2): annual average of the discounted initial capital investment of interventions plus discounted value of the fixed and variable costs in different UWS components to the first year with a specific discount rate.

(3) GHG emissions (C_3): annual average of the aggregated greenhouse gas emissions (GHG), as Global Warming Potential (GWP100) measured in units of carbon dioxide equivalents (CO_2-eq) from all components of the UWS.

(4) Leakage (C_4): Annual average of leakage volume is measured in all conveyance components of water supply assuming leakage is a fixed percentage of water supply in water supply conveyance components.

(5) CSO volume (C_5): Annual average of spill volume of CSOs (combined sewer overflow) is measured when daily flow in sewer network exceeds the capacity of a CSO structure.

(6) Social acceptance (C_6): the extent to which an intervention strategy would be supported by society, especially water consumers; in order to fulfil the water demands with respect to a number of factors especially safety and health issues.

Comparison of the intervention strategies with respect to the above performance metrics can be conducted based on either equal metric weights or some specific weighting schemes based on priorities of different groups/parties. For the sake of this analysis, three weighting schemes, including equal weights, Water Company and Consumer perspectives, are considered for ranking the intervention strategies (Table 3).

Table 3. Weights of the metrics from different perspectives

|	Reliability of Supply	Total Costs	GHG emissions	Leakage	CSO volume	Social acceptance
Equal weights	1	1	1	1	1	1
Public	4	1	3	1	3	5
Water company	5	3	2	4	1	4

4. DSS Application

The developed DSS tool is used here to demonstrate the assessment of aforementioned intervention strategies with respect to the specified performance indicators for the challenges of a long-term planning for this UWS which is facing likely future population growth. Therefore, a step-by-step procedure for setting up and running the DSS for the analysis of the aforementioned real life problem is described in the following.

Before running the DSS, the input data need to be specified and populated through the buttons in the configuration menu or left-hand pane as shown in Fig. 2. Input data requires specifying the following four steps which will be described in the next section in more detail:

  (1) Specification of general data describing the problem analysed;
  (2) Specification of scenarios and associated data;
  (3) Specification of performance metrics and associated data.
  (4) Specification of intervention strategies (Alternatives) and associated data;

For three parts of these data (i.e. Scenario, Metrics and Alternatives), there are four buttons available in the top ribbon menu for the user to **Add**, **Edit**, **Clone** and **Delete** the associate data. These buttons are explained below in further details when describing each group of input data of the case study problem. Once the program is opened, the the existing built model in this demo is uploaded automatically.
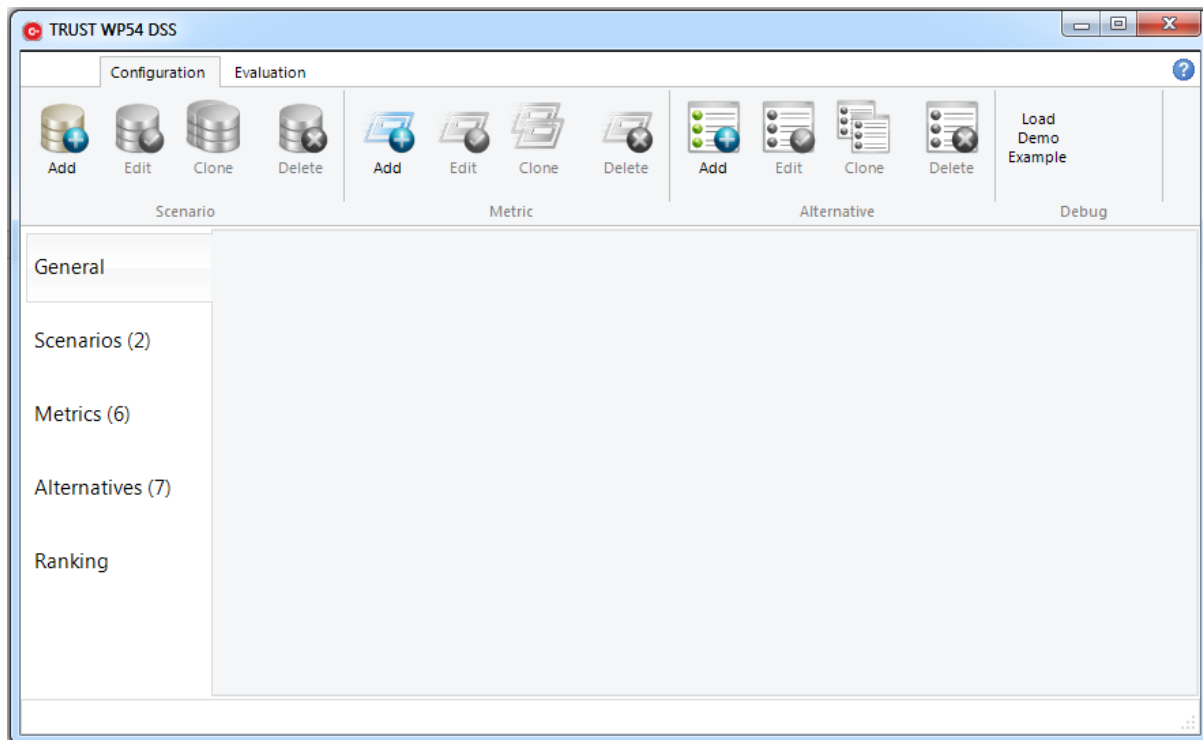
Fig. 2 General layout of the DSS

4.1 General Data

Using the GUI of the DSS software, the following data, according the information in section 2, is defined for the general data of case study problem:

- Name/description: Long-term planning of the a northern European city water supply system
- Planning horizon start year: 2011
- Planning horizon time steps: 30 time steps, each 1 year-long (i.e. end of planning horizon in year 2040)

4.2 Specification of Scenarios

The following specifications of the two scenarios of the case study problem described in Tables 1 and 2 are added in the Scenario section of the DSS by clicking **Add** button as shown in Fig. 3:

Scenario types and related information supported by the DSS are shown in Table 1. Each scenario is defined in the DSS as follows:

1. Scenario#1
   a. ID: Low Growth
   b. Description: Low Population Growth
   c. Type: Water Demand Growth
   d. Variable(s): The three variables with annual time series values listed in Table 1 are specified in this scenario.
2. Scenario#2
   a. ID: High Growth
   b. Description: High Population Growth
   c. Type: Water Demand Growth
   d. Variable(s): The three variables with annual time series values listed in Table 2 are specified in this scenario

Note that as soon as a "Water Demand Growth" type is selected from dropdown box, the associated variables (here four variables) are automatically shown. If the user tends to include the scenario in ranking, the relevant checkbox in this form needs to be checked otherwise it can be left unchecked or check needs to be cleared in the checkbox. Once a scenario is build, it can be edited, cloned (a quick way to make a new one based on the data in one of the build scenario) and deleted by double clicking on the relevant scenario in the list of existing scenarios. Finally, the input data for both scenarios in the case study problem are populated in the relevant form (Fig. 4).

Fig. 3 A sample form in the DSS for adding a new scenario


Fig. 4 Populated input data for both scenarios of the case study problem in the DSS

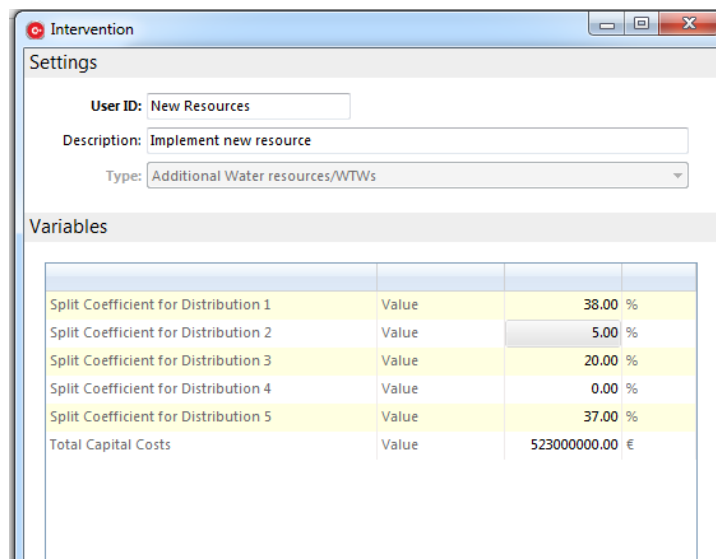## 4.3 Specification of Intervention Strategies

The third step is to define intervention strategies as a set of individual interventions, each applied at pre-specified point in time over the planning horizon. Therefore, the specifications of the seven intervention strategies described in section 2 are added in the **Alternative** section of the DSS based on the data in Table 4. In the DSS, a new intervention strategy can be added by clicking **Add** button in **Alternative** section of the **Configuration** ribbon menu (Fig. 1). For each intervention strategy, a new individual intervention option can be added by clicking **Add** button in the form of intervention strategy for which the individual intervention option is intended (Fig. 5). In the form of individual intervention option, associated variables is displayed once the user selects the type of interest. A

sample of populated individual intervention option (for Intervention Strategy 2) is shown in Fig. 6. As such, a sample of populated intervention strategy (for Intervention Strategy 7) is shown in Fig. 5.
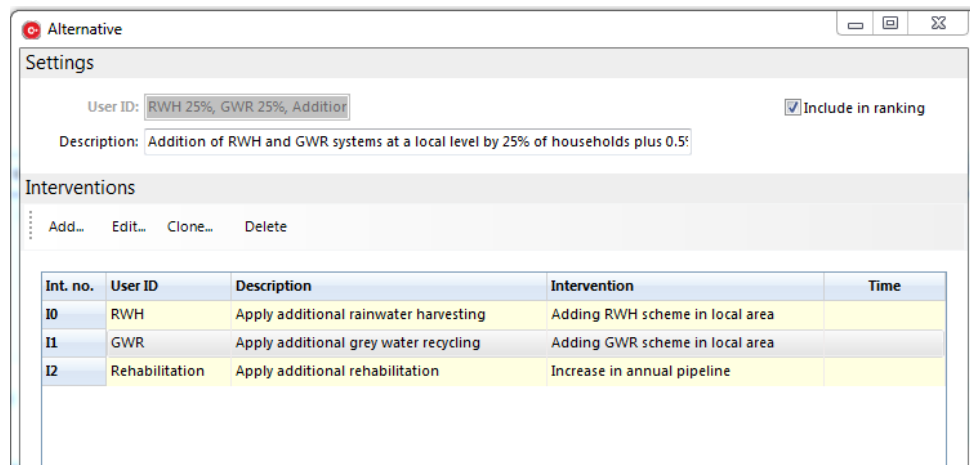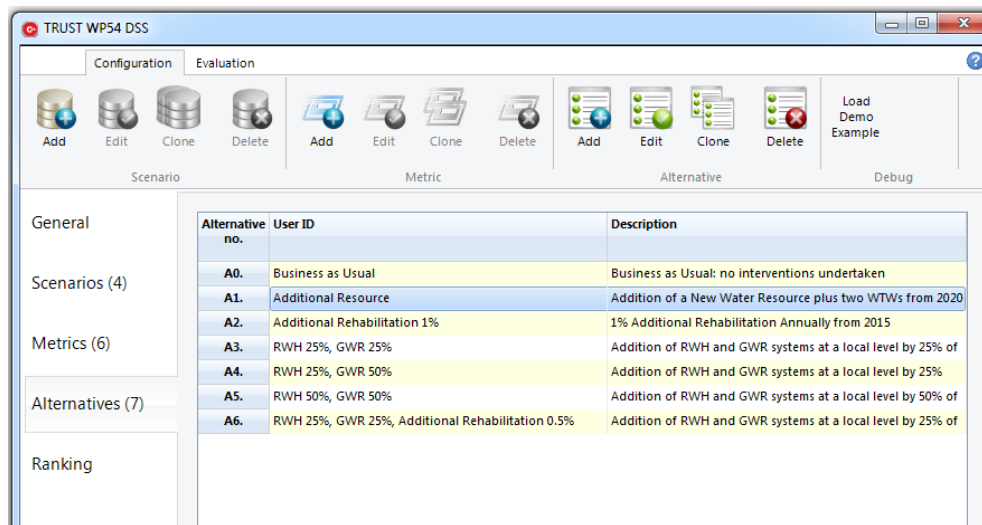

Fig. 5 An intervention strategy populated for the case study problem in the DSS

Fig. 6 An individual intervention option populated for the case study problem in the DSS

Finally, the list of intervention strategies is completed as shown in Fig. 7 for the seven intervention strategies of the case study problem in the DSS.

Fig. 7 List of populated intervention strategies for the case study problem in the DSS

Table 4. Specifications of the intervention strategies specified in the numerical example

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
1	Business as usual	None	None	None
2	Addition of a new water resource along with two WTWs starting from 2020	Description: New water resource/WTWs Occurrence type: one-off First occurrence: 2020 Location: water resources/WTWs Variables: ID=1 Name= Split percentage for distribution mains Units=% Component ID= 1 Magnitude= 38 ID =2 Name= Split percentage for distribution mains Units=% Component ID= 2 Magnitude= 5 ID =3 Name= Split percentage for distribution mains		

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
		Units=% Component ID= 3 Magnitude= 20 ID =4 Name= Split percentage for distribution mains Units=% Component ID= 5 Magnitude= 37 ID =5 Name= Total Capital Costs Units= Euros Magnitude= 523×10^6		
3	1% additional rehabilitation annually starting from 2015	Description: Increase in annual pipeline rehabilitation rate Occurrence type: recurring First occurrence: 2015 Frequency: once a year Time period: 25 years Location: Distribution mains Variables: ID =1 Name= Leakage Rate Component ID= subcatchment 1 Magnitude= 1 %		
4	addition of RWH and GWR systems at a local level by 25% of households starting from 2015	Description: Adding RWH scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m^3 Magnitude= 240,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1	Description: Adding GWR scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m^3 Magnitude= 19,500 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1	

| Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
		Units= Euros Magnitude= 127,200,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 5,760,000 ID =4 Name= Allocation of green water from RWH tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from RWH tank for industrial consumption in subcatchment 1 and local area 1 Magnitude =True ID =6 Name= Allocation of green water from RWH tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	Units= Euros Magnitude= 29,500,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 750,000 ID =4 Name= Allocation of green water from GWR tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from GWR tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6 Name= Allocation of green water from GWR tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	
5	addition of RWH and GWR systems at a local level by 25% and 50% of households, respectively, starting from 2015	Description: Adding RWH scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m³	Description: Adding GWR scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m³	

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
		Magnitude= 240,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 127,200,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 5,760,000 ID =4 Name= Allocation of green water from RWH tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from RWH tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6 Name= Allocation of green water from RWH tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	Magnitude= 39,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 59,000,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 1,500,000 ID =4 Name= Allocation of green water from GWR tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from GWR tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6 Name= Allocation of green water from GWR tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	
6	addition of RWH and GWR systems at a local level by 50% of households starting from	Description: Adding RWH scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables:	Description: Adding GWR scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables:	

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
	2015	ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m^3 Magnitude= 480,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 254,400,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 11,520,000 ID =4 Name= Allocation of green water from RWH tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from RWH tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6 Name= Allocation of green water from RWH tank for irrigation consumption in subcatchment 1 and local area 1 Units=-	ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m^3 Magnitude= 39,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 59,000,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 1,500,000 ID =4 Name= Allocation of green water from GWR tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Magnitude =True ID =5 Name= Allocation of green water from GWR tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6 Name= Allocation of green water from GWR tank for irrigation consumption in subcatchment 1 and local area 1 Units=- Magnitude =True	

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
		Magnitude =True		
7	addition of RWH and GWR systems at a local level by 25% of households and 0.5% additional rehabilitation annually starting from 2015	Description: Adding RWH scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m³ Magnitude= 240,000 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 127,200,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 5,760,000 ID =4 Name= Allocation of green water from RWH tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from RWH tank for industrial consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =6	Description: Adding GWR scheme in local area Occurrence type: One-off First occurrence: 2015 Location: local area Variables: ID =1 Name= Storage capacity Component ID= subcatchment 1 and local area 1 Units= m³ Magnitude= 19,500 ID =2 Name= Capital cost Component ID= subcatchment 1 and local area 1 Units= Euros Magnitude= 29,500,000 ID =3 Name= O&M cost Component ID= subcatchment 1 and local area 1 Units= Euros/year Magnitude = 750,000 ID =4 Name= Allocation of green water from GWR tank for Toilet consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True ID =5 Name= Allocation of green water from GWR tank for industrial consumption Component ID= subcatchment 1 and local area 1 Magnitude =True ID =6	Description: Increase in annual pipeline rehabilitation rate Occurrence type:: Recurring First occurrence: 2015 　Frequency: once a year 　Time period: 25 years Location: Distribution mains Variables: ID =1 Name= Leakage Rate Component ID= subcatchment 1 Units=% Magnitude= 0.5

Intervention Strategy ID	Intervention strategy description (name)	Individual Intervention 1	Individual Intervention 2	Individual Intervention 3
		Name= Allocation of green water from RWH tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	Name= Allocation of green water from GWR tank for irrigation consumption Component ID= subcatchment 1 and local area 1 Units=- Magnitude =True	

In the fourth step of the input data in the **Configuration** ribbon button, metrics are defined. Similar to other input data, a new performance metric can be added in the DSS by clicking **Add** button in the **Configuration** ribbon button. In the new form (Fig. 8), WaterMet2 metrics can be selected from a dropdown box once the checkbox of Use-supplied metric is unchecked. The user also needs to specify the three parameters related to the processing (i.e. Aggregation type, resampling type and consolidation) of performance indicators required when assessing with respect the metrics (Fig. 8).
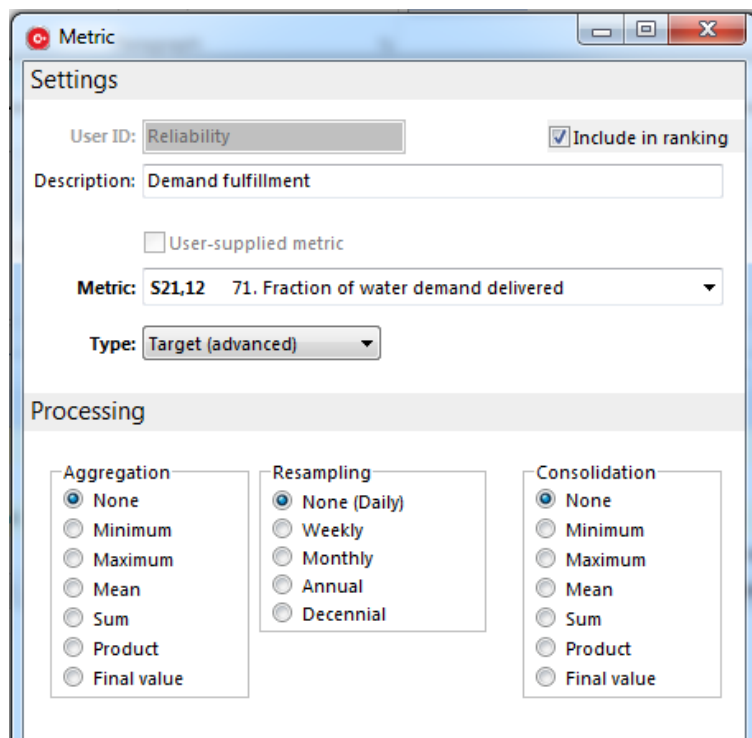
Fig. 8 A performance metric (reliability) populated for the case study problem in the DSS

The populated table of performance metrics for the case study problem in the DSS is shown in Fig. 9.

Fig. 9 Populated performance metric table for the case study problem in the DSS

After completing the four steps of the input data in the Configuration ribbon menu, the assessment and then ranking of intervention strategies are conducted. Assessment of the intervention strategies are carried out in two distinct steps of automatic and manual population. The first step is to automatically calculate the metrics which can be quantified by WaterMet[2]. This can be done by clicking **Populate Matrix** button. Other metrics which need to be quantified manually using either external tools or in a qualitative method. These metrics are those which the user has checked them when defining them in the relevant metric form. The manual metrics are clearly recognised by their distinct pink colour in the Decision Matrix Table. In the case study problem, five out of six metrics are quantified automatically by WaterMet2 and the only qualitative metric (C_6) is quantified by relevant experts and the quantified values incorporated in the DSS. Instead of using qualitative categories (linguistic terms) for metric C_6, these are rated as scoring on a scale of acceptance ranging from 1 to 10, being: extremely low (1-2), low (3-4), medium (5-6), high (7-8) and extremely high (9-10). Finally the Quantified performance metrics for each intervention strategy in the case study problem in the DSS is obtained as shown in Fig. 10.
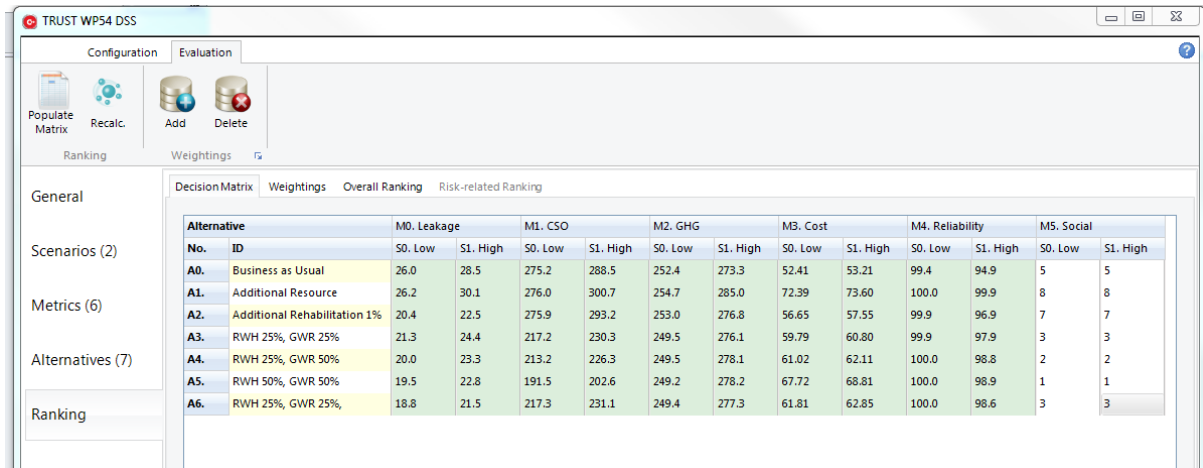
Fig. 10 Quantified performance metrics for each intervention strategy in the case study problem in the DSS

Then, the DSS needs to have associated target/goals and preferences, described in the following sections. The three sets of weighting schemes are populated in the **weighting** tab of the **Ranking** section in the DSS (Fig. 11). A new set of weighting scheme can be added by clicking Add button in the **Evaluation** ribbon menu. The List of the three weighting schemes populated for the case study problem in the DSS is shown in Fig. 11.
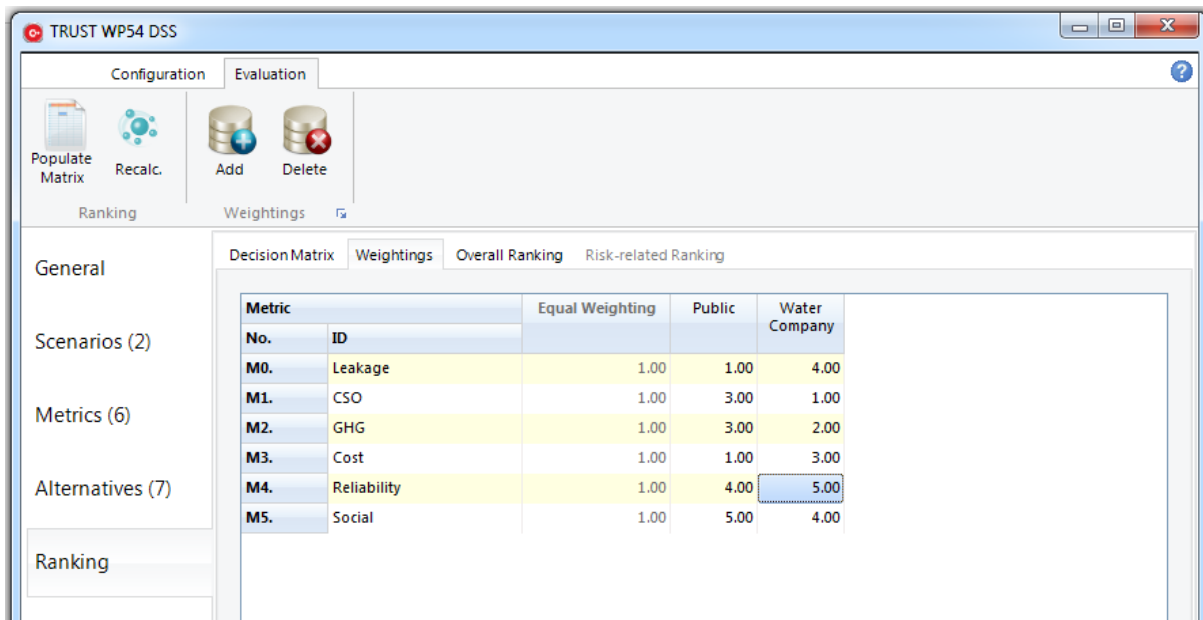
Fig. 11 List of the three weighting schemes populated for the case study problem in the DSS

Finally the ranking of the intervention strategies is obtained for all scenarios in the DSS by clicking **Recacl.** Button in the **Evaluation** ribbon menu. This is shown in Fig. 12 for the case study problem in the DSS. This ranking is obtained based on the Compromise Programming (CP) MCDA method (Zeleny 1973). A colour scale has been used to recognise the ranking of intervention strategies such that the high ranked intervention strategies are seen by a darker colour.

Fig. 12 Ranking table of intervention strategies including overall ranking obtained for all scenarios in the case study problem in the DSS

5. Summary

This document illustrates briefly, on a real-life example, how to use the TRUST DSS for the long-term planning of integrated urban water systems. A more comprehensive description of the DSS methodology, software tool and demonstration on a real-life example will be provided in the final report (Deliverable 54.3) which is due later on (end of project).

References

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6. Appendix. DSS Software Installation

Before installing the software, the user needs to check the system requirements to ensure that it is fully compatible with the software requirements. After a successful installation, the user can start

working on either a new model or existing model. The software tool is freely available for the users and can be accessible through either upon request from the developers or the TRUST website.

6.1 System requirements

The system requirements for installing the software are as follows:

- Operating System: Windows 8, Windows Server 2012, Windows 7, Windows Vista SP1 or later, Windows XP SP3, Windows XP SP2 x64 Edition, Windows Server 2008 (Server Core not supported), Windows Server 2008 R2 (Server Core supported with SP1 or later), Windows Server 2003 SP2
- DSS uses Windows™ based screens, and navigational devices such as buttons, drop-down menus and toolbars. The Minimum Screen Resolution is 1152x864 but a resolution of 1680x1050 or higher is highly recommended.
- Windows Regional Settings: any language is allowed when installing the software. However, for using the examples in the case study section, it is recommended to set for those languages (e.g. English) which recognises "." as decimal sign in Windows and Microsoft Office.
- Microsoft Excel 2000 or later - English Edition for viewing output files

6.2 Installation and running

The DSS software model is designed to run under a Windows™ operating system. It is distributed in as a compressed folder which includes a WP54DSS.EXE file which runs the program on Windows. The contents of the compressed folder should be extracted to the same directory. In order to run this executable file, the user merely needs to double-click on the WP54DSS.EXE file (Fig. A.1). Note that the two DLL files in the distributed folder (borlndmm.dll and cc32140mt.dll) must be kept in the same folder when running the DSS tool.
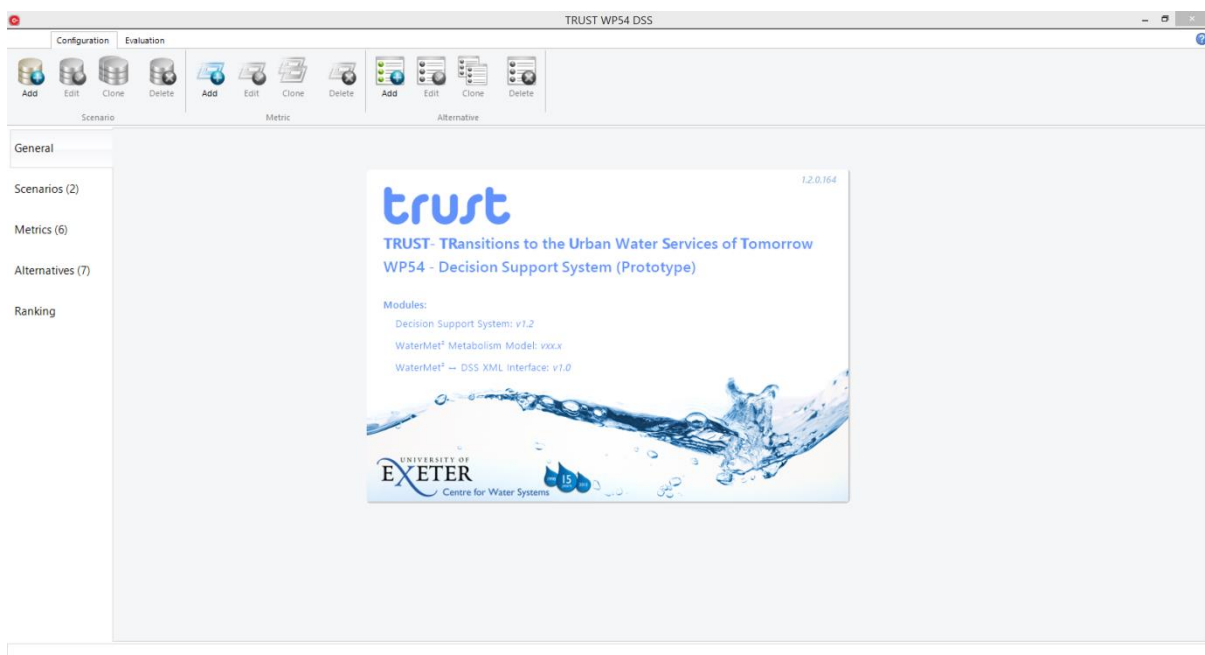
Fig. A.1 The initial appearance of the DSS software tool on start-up