

Supplementary material for
Stakeholder interviews with two MAVT preference
elicitation philosophies in a Swiss water infrastructure
decision: aggregation using SWING-weighting and
disaggregation using UTA^{GMS}

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1. Attributes

Table SM-1: Attributes quantifying the lowest level objectives and ranges. We also show the performance of the six decision alternatives (A2–A9) on these attributes. VSA = Swiss Association of Wastewater and Water Protection. CSOs = Combined Sewer Overflows. EFQM = European Foundation for Quality Management. More details are given in (Lienert et al., 2015; Zheng et al., 2016)

Short name	Attribute	A2	A5	A7	A8a	A8b	A9
rehab	Realization of the rehabilitation demand [%]	60	1	100	100	100	1
adapt	Flexibility of technical extension or deconstruction of infrastructure [%]	20	63	65	35	65	30
chem	Average water quality (evaluated on [0,1] scale) of reference points	77	75	77	77	77	77
hydr	% Reference points that fulfill VSA guidelines for stormwater handling [%]	37	37	37	37	37	37
exfiltrsew	Water quality based on nutrients evaluated on [0,1] scale	0.67	0.55	0.72	0.72	0.72	0.55
exfiltrstruct	Water quality based on biocides evaluated on [0,1] scale	1	1	1	1	1	1
phosph	Recovery of phosphate from wastewater [%]	0	0	90	0	0	0
econs	Net energy consumption for wastewater treatment and transport [kWh/ person/ year]	27	4	80	21	158	21
illn	% Of total population getting infected once per year [%]	1	1	4	1	4	1
cso	Number of CSOs / year / receiving water [no./ year/ receiving water]	13.84	13.84	13.84	13.84	0.00	13.84
failure	Weighted number of pipe collapses and blockages per year and 1'000 inhabitants	0.00	0.01	0.00	0.00	0.00	0.01
service	Weighted number of incidents of insufficient drainage capacity per year (e.g. over-flowing of manholes) [no./ year]	0.17	0.17	0.17	0.17	0.17	0.17
efqm	Score of EFQM Excellence Model	0.69	0.33	0.62	0.63	0.63	46
voice	Degree of co-determination	0.5	0.9	0.65	0.7	0.70	0.1
time	Necessary time investment for operation and maintenance by end user [hours/ person/ year]	0.00	2.53	3.78	1.88	3.78	1.88
area	Additional area demand on private property by end user [m^2 / person/ year]	0	0	0.08	0	0.60	0
collab	Number of infrastructure sectors that collaborate in planning and construction	6	2	6	2	2	1
costcap	Annual costs [CHF/ person/ year]	175	109	226	234	516	157
costchange	Mean annual increase of costs until 2050 [CHF/ person/ year]	2.12	0.03	1.86	1.95	-0.05	0.02

2. Preference elicitation methods

2.1. Weight elicitation with the SMART/SWING-variant

2.1.1. An illustrative example

We present an illustrative example for the elicitation of preferences concerning the main objective *Intergenerational equity*, which has two sub-objectives “Low future rehabilitation burden (rehab)” and “Flexible system adaptation (adapt)”.

The definition as well as the best and worst evaluations of the two sub-objectives were given to the stakeholders in an information letter sent to them two weeks before the interview. The status quo was presented as reference information. In the interview, the interviewer used the visualization as in Figure SM-1 to remind the stakeholders of the information.

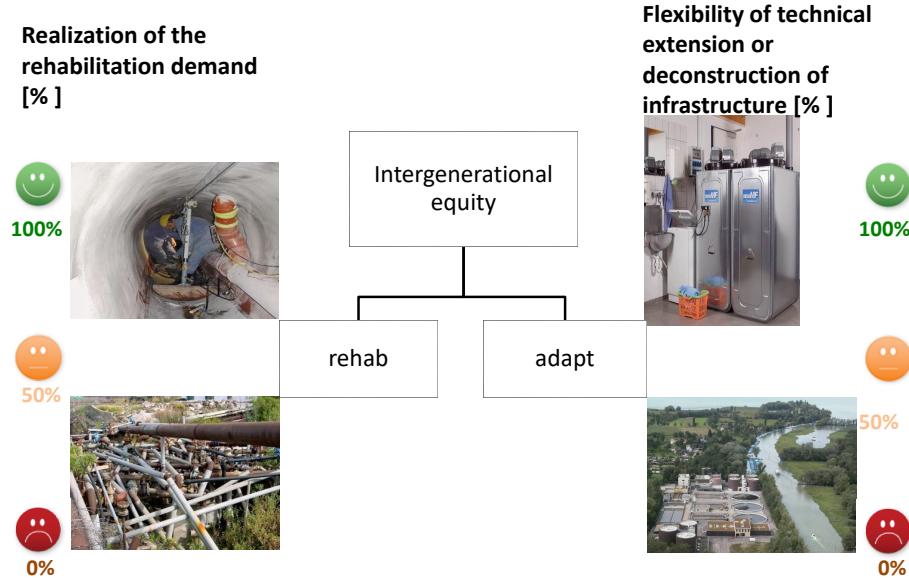


Figure SM-1: Visualization presented to the stakeholder to show the best, worst, and moderate evaluations of the two sub-objectives: “rehab” and “adapt”.

Note: Currently, 80% to 100% of the total rehabilitation demand is being realized. The system with centralized wastewater treatment plants is not very flexible (20 – 50% flexibility).

Because there were only two objectives, it was unnecessary to choose a reference. So the elicitation of weights involved two questions. The first was to rank the two sub-objectives according to their importance within the range. The formulation of the question is shown in Box 1. The second question asked for

the strength of preference if indifference was not stated for the first question. The question was formulated as in Box 2.

Box 1. Elicitation of the ranking of objectives using the SMART/SWING-variant: Choice of one sub-objective to improve.

Compare two objectives

Suppose the following two sub-objectives are in the worst-possible state.

Objective A: Low rehabilitation burden until 2050



Best case: Proactive renewal, renovation, and replacement measures are being carried out (100% realization of the rehabilitation demand). The state of the wastewater system remains about as good as it is today.



Worst case: No renewal, renovation, or replacement is being carried out (0% realization of the rehabilitation demand). Hence, all negative legacy is burdened onto the next generation.

Objective B: Flexible system adaption



Best case: The system is very flexible (100% flexibility). It is easily and quickly possible to adapt the capacities to changed requirements.



Worst case: The system is very inflexible (0% flexibility) and the technical extension or deconstruction of the system is very difficult.

You can now choose one objective that you want to improve to the best-possible state. Or is it equally important to you that both objectives get improved to the best-possible state?

Please choose one of the options:

1. It is more important for me to improve objective A compared to objective B from the worst to the best-possible state.
2. It is more important for me to improve objective B compared to objective A from the worst to the best-possible state.
3. I cannot see the difference, both improvements are exactly equally important to me.

Box 2. Elicitation of weights using the SMART/SWING-variant: Indication of strength of preference.

Strength of the importance

You stated that improving Objective A from the worst to the best-possible case is more important to you than improving Objective B from the worst to the best-possible case.

We would like to know how much more important this first improvement is? Please complete the _____ in the following sentence by choosing from one of the nine categories C_1, \dots, C_9 : An improvement of the objective A from the worst to the best case is _____ than (as) an improvement in the objective B from the worst to the best case.

(C_1 : equally important; C_3 : somewhat more important; C_5 : more important; C_7 : much more important; C_9 : extremely more important; C_2, C_4, C_6, C_8 : between categories)

Objective A: Low rehabilitation burden until 2050



Best case: Proactive renewal, renovation, and replacement measures are being carried out (100% realization of the rehabilitation demand). The state of the wastewater system remains about as good as it is today.



Worst case: No renewal, renovation, or replacement is being carried out (0% realization of the rehabilitation demand). Hence, all negative legacy is burdened onto the next generation.

Objective B: Flexible system adaption



Best case: The system is very flexible (100% flexibility). It is easily and quickly possible to adapt the capacities to changed requirements.



Worst case: The system is very inflexible (0% flexibility) and the technical extension or deconstruction of the system is very difficult.

2.1.2. Elicited preferences of the example

One stakeholder stated that improving the objective “rehab” was extremely more important than improving the objective “adapt” from the worst to the best-possible case. This could be interpreted as $\frac{w_{\text{rehab}}}{w_{\text{adapt}}} = 9$. We can then calculate that $w_{\text{rehab}} = 0.9$ and $w_{\text{adapt}} = 0.1$ with the constraint that the two weights add up to unity.

2.2. Preference elicitation procedure using the UTA^{GMS} method

2.2.1. An illustrative example

We present an illustrative example for the elicitation of preferences with the UTA^{GMS} procedure again concerning the main objective *Intergenerational equity*. A typical elicitation process is:

Interaction 1: We presented a pairwise comparison $\text{Comp}_1 : C(a_3, a_7)$ to the stakeholder (see Tab. 1 in main text) and asked which option was preferred or whether both were equally good (using the visualization with emoticons as in Box 3). Then the strength of preference was elicited (Box 4) using the nine AHP-type categories to choose from (C_1 : “there is no difference between the alternatives” to C_9 : “there is an extreme difference”; see Methods in main text).

Box 3. Pairwise comparison: Choice of a preferred alternative.

There are two wastewater infrastructure system options. Option A is that we have a system which realizes a very high proportion of the rehabilitation demand but is very inflexible to change. Option B is that the rehabilitation is barely implemented and left to the next generation while the infrastructure is easy to adapt to future changes. Which option do you prefer? Or are the two options equally good to you?

Option A: a_3

rehab	adapt

100% 0%

Option B: a_7

rehab	adapt

0% 100%

?

Box 4. Pairwise comparison: Indication of strength of preference.

Strength of the pairwise comparison

You stated that Option A is better than Option B. We would like to know how much is the difference of attractiveness between the two alternatives? Please complete the _____ in the following sentence by choosing one of the given nine categories: The difference of attractiveness between a_3 and a_7 is _____.

- | | |
|--|---|
| <input type="radio"/> Negligible (C_1) | <input type="radio"/> Between C_1 and C_3 |
| <input type="radio"/> Weak (C_3) | <input type="radio"/> Between C_3 and C_5 |
| <input type="radio"/> Moderate (C_5) | <input type="radio"/> Between C_5 and C_7 |
| <input type="radio"/> Strong (C_7) | <input type="radio"/> Between C_7 and C_9 |
| <input type="radio"/> Extremely strong (C_9) | |

Suppose that the stakeholder's response to the above two questions was that in the comparison of alternatives a_3 with a_7 , the alternative a_3 was preferred (answer to question in Box 3), and that the strength of preferences was such that there was a weak difference (i.e. C_3) between a_3 being better than a_7 (answer to question in Box 4). This can be denoted as: $C(a_3 \succ a_7) \in C_3$, whereby two new necessary weak preference relations were also found: Comp₄ : $a_3 \succ a_4$ and Comp₈ : $a_6 \succ a_7$. We estimated the number of necessary weak preference relations generated if one of the six remaining pairwise comparisons was known. We found that the six remaining comparisons would lead to the same number of necessary weak dominance relations. For example, for both Comp₂ : $C(a_2, a_7)$ and Comp₅ : $C(a_3, a_5)$, the number of derived necessary weak preference relations were 4 if this specific comparison was determined (Tab. SM-2).

Table SM-2: New necessary weak preference relation for two pairwise comparisons. We present the new necessary weak preference relations with the assumption that the stakeholder responds to the question in a particular way. N/A means no new necessary weak preference. For example, if we ask the stakeholder to compare a_2 and a_7 and she responds that $a_2 \succ a_7$, two more necessary weak preferences are generated: $a_2 \succ a_4$ and $a_5 \succ a_7$.

Comparison	Response	New necessary weak preference relations
$C(a_2, a_7)$	$a_2 \succ a_7$	$a_2 \succ a_4; a_5 \succ a_7$
	$a_7 \succ a_2$	N/A
	$a_2 \sim a_7$	$a_2 \succ a_4; a_5 \succ a_7$
$C(a_3, a_5)$	$a_3 \succ a_5$	N/A
	$a_5 \succ a_3$	$a_8 \succ a_3; a_5 \succ a_7$
	$a_3 \sim a_5$	$a_8 \succ a_3; a_5 \succ a_7$

Interaction 2 : We randomly chose $\text{Comp}_2 : C(a_2, a_7)$ (see Tab. 1) and presented this pair to the stakeholder in a similar form as in Box 3 and 4 (SM).

Suppose that the stakeholder said that alternative a_2 was preferred to alternative a_7 and that there was a moderate difference between these two alternatives, i.e. $\text{Comp}_2 : C(a_2 \succ a_7) \in C_5$. We added this preference information and calculated the number of questions for each of the three remaining comparisons. This time we found that $\text{Comp}_6 : C(a_3, a_8)$ would be the most informative question because either $a_3 \succ a_8$ or $a_3 \sim a_8$ would generate two new necessary relations which meant the ranking of a_1, \dots, a_9 was determined.

Interaction 3 : We asked the stakeholder about $\text{Comp}_6 : C(a_3, a_8)$ again in a similar form as in Box 3 and 4 (SM).

Let us assume that the stakeholder stated that $\text{Comp}_6 : C(a_3 \succ a_8) \in C_7$. Thus, the ranking was complete: $a_9 \succ a_6 \succ a_3 \succ a_8 \succ a_5 \succ a_2 \succ a_7 \succ a_4 \succ a_1$.

Interaction 4 : We asked the stakeholder to adjust the preferred alternative a_3 in the first comparison so that an indifference relation was obtained (the formulation of the question is given in Box 5).

Box 5. Trade-off question: eliciting indifference statements

Trade-off question

You stated that Option A is better than Option B

Option A: a_3		Option B: a_7	
rehab	adapt	rehab	adapt
100%	0%	0%	100%
?%	0%	=	0% 100%

Question 1: We would like to know: if the sub-objective “rehab” of a_3 is worsened to 50% and becomes a'_3 (which is in fact a_2), which alternative do you prefer? a'_3 or a_7 ?

The stakeholder had to say that $a'_3 \succ a_7$, otherwise she was inconsistent with the answer in interaction 2 (see above). To reach an indifference statement, we continued to worsen a'_3 .

Question 2: We would like to know: if the sub-objective “rehab” of a'_3 is worsened to 25% and becomes a''_3 , which alternative do you prefer? a''_3 or a_7 ?

If the stakeholder preferred a''_3 , then we kept on worsening the sub-objective “rehab” of a''_3 to 12.5%. Otherwise, we would improve the sub-objective “rehab” of a''_3 to 37.5%.

The questioning was continued until the stakeholder felt that a new alternative $a_?$ was more or less just as attractive/ unattractive as a_7 . Hence, we stopped at this indifference point of 30% in the example. We created a new hypothetical alternative a_{10} which realized 30% rehabilitation burden without any flexibility and set this equal in preference with alternative a_7 , which realized no rehabilitation, but had 100% flexibility, based on the above trade-off statements.

2.2.2. Elicited preferences of the example

By solving the linear program, a representative additive value function was obtained (see Fig. SM-2) based on the preferences stated above. The marginal value functions were constructed from the values of characteristic points in a piecewise manner. The weights of the two sub-objectives “rehab” and “adapt” were 0.91 and 0.09 respectively at this level of the objectives hierarchy.

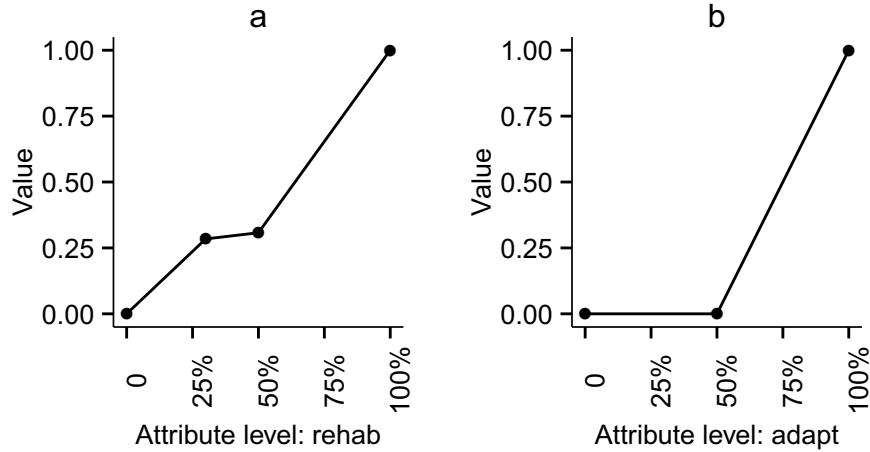


Figure SM-2: Marginal value functions for the two sub-objectives of the main objective *Intergenerational equity*. The x-axis represents attribute levels, and the short names of the attributes are presented in Table SM-1. The y-axis the achieved value between [0,1], where 0 means the respective sub-objective is not at all achieved (=worst possible level), and 1 that the respective sub-objective is fully achieved (=best possible level). The dots represent the numbers inferred by the linear program.

3. Results

3.1. Individual weights and rankings of objectives/ sub-objectives

Table SM-3: Weights of each stakeholder obtained in two interview series. For the definitions of the objectives and lowest-level sub-objectives, please refer to Figure 1 (the main text) and Table A.1 (Appendix). SH = stakeholder. For a specific objective/sub-objective, the numbers in first (second, resp.) row correspond to its importance within the whole objectives hierarchy with the SMART/SWING-variant (UTA^{GMS} , resp.).

Objective/ Sub-objective	SH1	SH2	SH3	SH4	SH5	SH6	SH7	SH8	SH9	SH10
Equity	0.608 0.409	0.091 0.183	0.382 0.206	0.303 0.336	0.105 0.029	0.079 0.013	0.056 0.031	0.128 0.147	0.043 0.128	0.094 0.136
Protection	0.122 0.301	0.639 0.387	0.127 0.309	0.258 0.271	0.345 0.347	0.550 0.546	0.395 0.313	0.383 0.412	0.217 0.274	0.188 0.278
Safe WW disposal	0.122 0.236	0.128 0.091	0.382 0.257	0.197 0.175	0.523 0.389	0.183 0.280	0.395 0.438	0.383 0.353	0.650 0.530	0.565 0.510
Social acceptance	0.068 0.000	0.071 0.274	0.055 0.083	0.106 0.012	0.012 0.154	0.079 0.046	0.056 0.078	0.064 0.029	0.046 0.034	0.072 0.005

Table SM-3: continued

Objective/ Sub-objective	SH1	SH2	SH3	SH4	SH5	SH6	SH7	SH8	SH9	SH10
Low costs	0.081 0.054	0.071 0.065	0.055 0.145	0.136 0.206	0.015 0.081	0.110 0.115	0.099 0.141	0.043 0.059	0.043 0.034	0.081 0.071
rehab	0.547 0.221	0.082 0.131	0.334 0.127	0.265 0.233	0.052 0.013	0.059 0.007	0.048 0.021	0.064 0.090	0.036 0.088	0.082 0.045
adapt	0.061 0.188	0.009 0.051	0.048 0.079	0.038 0.103	0.052 0.016	0.020 0.006	0.008 0.010	0.064 0.057	0.007 0.040	0.012 0.091
chem	0.007 0.094	0.261 0.076	0.012 0.037	0.047 0.066	0.222 0.153	0.231 0.155	0.092 0.091	0.160 0.146	0.026 0.030	0.079 0.068
hydr	0.050 0.058	0.029 0.031	0.002 0.021	0.047 0.064	0.032 0.066	0.026 0.135	0.092 0.051	0.020 0.062	0.026 0.023	0.010 0.030
exfiltrsew	0.050 0.093	0.242 0.124	0.049 0.126	0.125 0.052	0.053 0.069	0.128 0.060	0.092 0.075	0.159 0.079	0.077 0.126	0.044 0.098
exfiltrstruct	0.007 0.041	0.048 0.081	0.049 0.078	0.018 0.046	0.011 0.059	0.128 0.079	0.092 0.040	0.021 0.077	0.077 0.059	0.044 0.046
phosph	0.001 0.002	0.048 0.017	0.007 0.018	0.018 0.018	0.014 0.000	0.009 0.058	0.013 0.029	0.011 0.028	0.003 0.008	0.006 0.019
econs	0.007 0.013	0.010 0.059	0.007 0.028	0.004 0.024	0.014 0.000	0.027 0.059	0.013 0.026	0.011 0.020	0.009 0.028	0.006 0.016
illn	0.018 0.023	0.011 0.015	0.159 0.085	0.027 0.045	0.055 0.114	0.046 0.184	0.235 0.176	0.272 0.222	0.488 0.380	0.420 0.335
cso	0.091 0.014	0.096 0.056	0.032 0.042	0.137 0.029	0.382 0.228	0.046 0.052	0.028 0.101	0.034 0.075	0.054 0.107	0.049 0.094
failure	0.002 0.115	0.019 0.012	0.032 0.087	0.029 0.082	0.011 0.024	0.023 0.010	0.066 0.109	0.064 0.028	0.027 0.016	0.081 0.055
service	0.010 0.084	0.003 0.009	0.159 0.043	0.003 0.018	0.076 0.023	0.069 0.035	0.066 0.053	0.013 0.028	0.081 0.027	0.015 0.025
efqm	0.044 0.000	0.005 0.055	0.013 0.026	0.006 0.005	0.004 0.028	0.030 0.020	0.009 0.024	0.039 0.011	0.029 0.014	0.060 0.002
voice	0.006 0.000	0.049 0.135	0.003 0.015	0.001 0.000	0.000 0.038	0.006 0.008	0.001 0.017	0.004 0.006	0.006 0.007	0.001 0.000
time	0.006 0.000	0.005 0.022	0.013 0.013	0.021 0.001	0.003 0.045	0.006 0.002	0.044 0.028	0.017 0.005	0.004 0.005	0.007 0.001
area	0.006 0.000	0.005 0.028	0.013 0.010	0.031 0.002	0.000 0.025	0.006 0.003	0.001 0.008	0.002 0.000	0.004 0.004	0.001 0.001
collab	0.005 0.000	0.005 0.033	0.013 0.019	0.047 0.003	0.004 0.018	0.030 0.013	0.001 0.001	0.001 0.007	0.003 0.003	0.002 0.001
costcap	0.061 0.019	0.009 0.021	0.027 0.101	0.023 0.093	0.007 0.019	0.096 0.047	0.049 0.094	0.038 0.030	0.033 0.021	0.040 0.030
costchange	0.020 0.036	0.062 0.045	0.027 0.043	0.114 0.113	0.007 0.063	0.014 0.068	0.049 0.047	0.005 0.029	0.011 0.013	0.040 0.041

Table SM-4: Ranking of weights of each stakeholder obtained in two interview series. For a specific main objective/ lowest-level sub-objective, the numbers in first (second, resp.) row correspond to the ranking of its importance obtained with the SMART/SWING-variant (UTA^{GMS}, resp.). The number corresponding to a main objective reflects its importance compared with the other four main objectives; rank 1 = the most important main objective among the five. The number corresponding to a lowest level sub-objective reflects its importance compared with the other 18 lowest level sub-objectives; rank 1 = the most important lowest-level sub-objective of the 19. Other explanations see Table SM-3.

Objective/ Sub-objective	SH1	SH2	SH3	SH4	SH5	SH6	SH7	SH8	SH9	SH10
Equity	1 1	3 3	1 3	1 1	3 5	4 5	5 5	3 3	4 3	3 3
Protection	2 2	1 1	3 1	2 2	2 2	1 1	1 2	1 1	2 2	2 2
Safe WW disposal	3 3	2 4	2 2	3 4	1 1	2 2	2 1	2 2	1 1	1 1
Social acceptance	5 5	4 2	4 5	5 5	5 3	5 4	4 4	4 5	3 4	5 5
Low costs	4 4	5 5	5 4	4 3	4 4	3 3	3 3	5 4	5 5	4 4
rehab	1 1	4 2	1 1	1 1	6 17	6 16	10 15	5 3	6 4	2 8
adapt	3 2	13 9	6 6	8 3	7 16	14 17	16 17	6 8	14 6	12 4
chem	12 4	1 5	15 11	6 6	2 2	1 2	2 5	2 2	10 7	4 5
hydr	5 7	9 12	19 14	7 7	8 5	12 3	3 8	11 7	11 10	13 10
exfiltrsew	6 5	2 3	4 2	3 8	5 4	2 6	4 6	3 4	3 2	7 2
exfiltrstruct	13 8	8 4	5 7	14 9	12 7	3 4	5 10	10 5	4 5	8 7
phosph	19 14	7 16	16 16	15 13	9 18	16 8	13 11	14 13	19 15	15 13
econs	11 13	12 6	17 12	17 12	10 19	11 7	14 13	15 14	13 8	16 14
illn	9 10	11 17	2 5	11 10	4 3	7 1	1 1	1 1	1 1	1 1
cso	2 12	3 7	7 10	2 11	1 1	8 9	12 3	9 6	5 3	6 3
failure	18 3	10 18	8 4	10 5	11 12	13 14	6 2	4 11	9 12	3 6
service	10 6	19 19	3 9	18 14	3 13	5 11	7 7	13 12	2 9	11 12
efqm	7 15	15 8	11 13	16 15	15 10	9 12	15 14	7 15	8 13	5 15
voice	14 17	6 1	18 17	19 19	18 9	17 15	17 16	17 17	15 16	18 19
time	16	16	12	13	17	18	11	12	16	14

Table SM-4: continued

Objective/ Sub-objective	SH1	SH2	SH3	SH4	SH5	SH6	SH7	SH8	SH9	SH10
	18	14	18	18	8	19	12	18	17	16
area	15	17	13	9	19	19	19	18	17	19
	16	13	19	17	11	18	18	19	18	18
collab	17	18	14	5	16	10	18	19	18	17
	19	11	15	16	15	13	19	16	19	17
costcap	4	14	9	12	13	4	8	8	7	9
	11	15	3	4	14	10	4	9	11	11
costchange	8	5	10	4	14	15	9	16	12	10
	9	10	8	2	6	5	9	10	14	9

3.2. The number of questions during elicitation

Table SM-5: The number of questions when eliciting preferences for each objective/ sub-objective. SH = stakeholder. For the definitions of the objective/ sub-objective, see Figure 1 in the main text, and Table A.1 in the Appendix.

	SH1	SH2	SH3	SH4	SH5	SH6	SH7	SH8	SH9	SH10	alt ¹	all ²	ave. ³	max ⁴	min ⁵
Equity	7	5	7	5	7	4	6	7	5	7	9	9	6	7	4
Surface water	6	4	6	4	5	5	7	6	7	5	9	9	5.5	7	4
Ground water	5	7	6	4	7	6	9	4	5	5	9	9	5.8	9	4
Efficiency	4	5	5	6	5	1	6	7	4	7	9	9	5	7	1
Protection	3	5	4	5	5	5	5	5	4	5	8	6	4.6	5	3
Hygiene	4	5	7	8	7	4	7	5	4	4	9	9	5.5	8	4
High reliability	6	6	7	4	4	4	7	4	6	5	9	9	5.3	7	4
Safe WW disposal	2	2	1	2	2	2	2	2	2	2	4	2	1.9	2	1
Social acceptance	4	9	9	4	11	4	10	8	9	10	41	46	7.8	11	4
Low costs	7	4	4	5	4	5	6	4	6	7	9	9	5.2	7	4
Sustainable WWI	13	13	5	8	12	7	14	11	8	7	16	75	9.8	14	5

¹The number of alternatives to be ranked for each objective/ sub-objective.

²The number of all questions (all unknown pairwise comparisons after weak dominance relations are eliminated) needed for each objective/ sub-objective.

³The average number of questions for all stakeholders that we actually asked for each objective/ sub-objective.

⁴The maximum number of questions for all stakeholders that we actually asked for each objective/ sub-objective.

⁵The minimum number of questions for all stakeholders that we actually asked for each objective/ sub-objective.

4. Analyzing the MCDA results for two stakeholders

There were 19 marginal value functions and 19 *global* weights of lowest level sub-objectives in the MAVT models. Therefore, it was not straightforward to explain the changes of the overall values, as all these parameters could play a role. Nevertheless, we analyzed two cases of extreme changes (SH1 with the highest value change and SH9 with the greatest rank change) to address specifically two questions that interested us:

1. Why did the overall values of alternatives for stakeholder SH1 dramatically change?

We found that the changes in the overall values of the alternatives can be largely explained by the changes of preferences concerning the main objective *Intergenerational equity*. In the interview using the SMART/SWING-variant, the local weights of the sub-objectives “rehab” and “adapt” were computed as 0.9 and 0.1 respectively, from the statement that improving the realization of the rehabilitation demand was “extremely more important” (category C_9) than improving the flexibility of system adaptation (Tab. SM-6).

The marginal value function for “rehab” was elicited in detail with the bi-section method in the first interview, and a threshold of 70% was found. Any alternative with “rehab” below this threshold does not achieve the sub-objective “rehab” at all (Fig. SM-3a). For “adapt”, we used rough elicitation in the first interview and only obtained the information that the marginal value function was concave; we used an exponential function as approximation (Section 3.2 main text; Fig. SM-3b). In the second interview using UTA^{GMS}, the local weights and marginal value functions of “rehab” and “adapt” were inferred together from five preference and one indifference relation regarding ten hypothetical alternatives. The elicited parameters are shown in Table SM-6 and Figure SM-3.

Table SM-6: Weights of two sub-objectives of the main objective *Intergenerational equity* for stakeholder SH1 in the two interviews (the SMART/SWING-variant and UTA^{GMS}). The local weights of the two sub-objectives, namely realization of the rehabilitation demand (“rehab”) and flexibility for future adaptation (“adapt”) add up to unity. We also show the global weights of the two sub-objectives scaled by the weight of *Intergenerational equity*, which is 0.61 for the first interview using the SMART/SWING-variant, and 0.41 for UTA^{GMS} (A significant change occurred at the level of the five main objectives, see Tab. SM-3).

	SMART/SWING variant (local weights)	SMART/SWING variant (global weights)	UTA ^{GMS} (local weights)	UTA ^{GMS} (global weights)
rehab	0.9	0.55	0.54	0.22
adapt	0.1	0.06	0.46	0.19

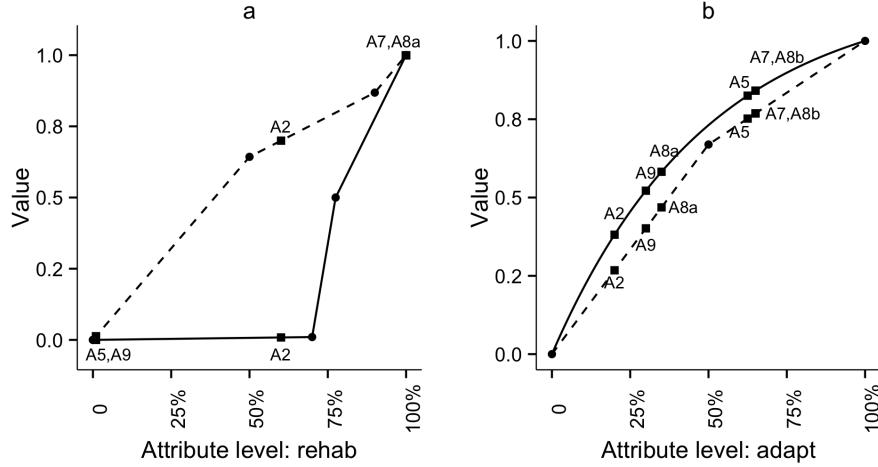


Figure SM-3: Marginal value functions for the two sub-objectives (attributes) of the main objective *Intergenerational equity* for stakeholder SH1. The attributes are realization of the rehabilitation demand (“rehab”, Fig. SM-3a) and the flexibility for adaptation to future changes (“adapt”, Fig. SM-3b). We show the results from the first interview with direct elicitation using the bi-section method or rough elicitation (solid line) and inferred indirectly in the second interview using UTA^{GMS} (dashed line). The x-axis represents the attribute levels, the y-axis the achieved value between [0,1], where 0 means that the sub-objective is not at all achieved (=worst possible level), and 1 that it is fully achieved (=best possible level). The dots represent the points elicited in the interview. The squares represent the respective attribute levels of the six alternatives (A2–A9) and the values that each alternative achieves (e.g. as extreme example in Fig. SM-3a: an alternative A₂ achieves 60% of the rehabilitation demand, but a value of 0 in the first interview).

With the changes in the weights and marginal value functions between the first and second interviews shown above (Tab. SM-6, Fig. SM-3), the values of the main objective *Intergenerational equity* significantly changed (Tab. SM-7). This can largely explain the dramatic changes of the overall values of the six alternatives between the first and second interview for stakeholder SH1.

Table SM-7: Changes in the overall values of the six alternatives in two interviews for the two sub-objectives (“rehab”, “adapt”) and the main objective *Intergenerational equity*, for stakeholder SH1. We compare the results from two elicitation methods: the first interview using the SMART/SWING-variant for weight elicitation and the bi-section method or rough estimates to elicit the shape of the value function; and the second interview using UTA^{GMS}.

	rehab		adapt		Intergenerational equity	
	The first	The second	The first	The second	The first	The second
A2	0	0.15	0.02	0.05	0.03	0.20
A5	0	0	0.05	0.14	0.05	0.15
A7	0.55	0.22	0.05	0.15	0.60	0.37
A8a	0.55	0.22	0.03	0.09	0.58	0.31
A8b	0.55	0.22	0.05	0.15	0.60	0.37
A9	0	0	0.03	0.08	0.03	0.08

We present the reactions and explanations of stakeholder SH1 after he saw the comparisons of the weightings of the five main objectives elicited in the two interviews in Table SM-8. It is interesting that he agreed with both weightings and thought they were similar. This is unsurprising as it is difficult to quantitatively express one’s preferences (Beinat, 1997).

2. Why was there nearly no correlation between the two rankings of alternatives for stakeholder SH9?

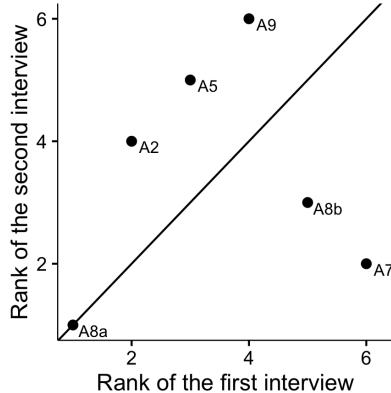


Figure SM-4: Ranks of the six alternatives (A2–A9) for stakeholder SH9 in the two interviews. The x-axis represents the ranks of alternatives in the first interview using the SMART/SWING-variant for weights and the bi-section method or rough elicitation for value functions; the y-axis represents the second interview using UTA^{GMS}. Alternatives having identical ranks across interviews appear on the diagonal line (only applies to the first-ranked alternative in both interviews, A8a).

Compared with the first interview using the SMART/SWIGN-variant, the global weights for “rehab” was higher in the second interview using UTA^{GMS}, increasing from

0.04 to 0.09 (Tab. SM-3). This is reasonable as the main objective *Intergenerational equity* was more important in the UTA^{GMS} interview (see Fig. 2 in main text; Tab. SM-3). However, the global weight for “illn” decreased from 0.49 in the first interview to 0.38 in the second interview. This change mainly stemmed from the lower weighting of the main objective *Safe wastewater disposal* in the second interview (Fig. 2 in main text; Tab. SM-3). The changes in the weights of the two attributes in the second interview thus more prominently emphasized the advantages of alternatives with a good performance on “rehab”, while the disadvantages of alternatives with bad performance on “illn” became less important. Alternatives A7, A8b and A8a performed best on the attribute “rehab” because of their rehabilitation strategy with a constant budget. However, alternatives A7 and A8b also suffered from the risk of people getting ill because of maintenance required by such decentralized systems, resulting in a bad performance on “illn”. Therefore, changes of weights for the two attributes can partly explain why A7 ranked much better in the second interview, where it received the second rank instead of the sixth along with a better ranking of A8b, which improved from the fifth to the third rank (Fig. SM-4).

We present the reactions and explanations of stakeholder SH9 after he saw the comparisons of the weightings elicited in the two interviews in Table SM-8.

5. Preferences inconsistencies and explanations by stakeholders

Table SM-8: Inconsistencies of preferences between the two interviews and explanations provided by the stakeholders (SH). We present the changes in the rankings of importance of objectives/ sub-objectives, the stakeholders' explanations for the changes, and how we categorized the explanations for inconsistency. Note that we did not necessarily ask for explanations for all inconsistencies due to time limit. Also there were cases that the weights of the two interviews were considered similar and generally consistent, so no categorizations were provided. We use \succ (\sim , resp.) to represent that one objective is more important than (equally important as, resp.) another objective considering the ranges. The short names of the objectives/ sub-objectives are defined in Table A.1 in the Appendix of the main text.

Objectives	Preference instability	Explanation	Category
Equity	SH6 1. Rehabilitation \succ <i>Flexibility</i> 2. Rehabilitation \sim <i>Flexibility</i>	SH6: He explained that the two objectives were related with each other. Therefore, making a decision was difficult.	SH6: uncertainty effect
SH10:		SH10: She explained that she had intensively researched about uncertainties in infrastructure planning for the future between interviews. Her previous opinions about decentralized systems and their high costs have changed. She now thought that if one wants to change the system, one needs to slowly change from central to decentralized, especially to build flexible systems in low populated areas and only to rehabilitate essential sewers in densely populated areas	SH10: learning effect

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
Surface water	SH1: 1. <i>Hydraulic impacts</i> \succ <i>Chemical state</i> 2. <i>Chemical state</i> \succ <i>Hydraulic impacts</i>	SH1: It is possible that there was a different understanding. He tried to consider which problem the environment can handle more easily. It could be that this would change again the next time. He had no strong preference regarding these two objectives, both were important.	SH1: different strategies; uncertainty
	SH7: 1. <i>Hydraulic impacts</i> \sim <i>Chemical state</i> 2. <i>Chemical state</i> \succ <i>Hydraulic impacts</i>	SH7: He made a decision today. As he focused on both objectives, it was difficult to decide. The objective <i>Chemical state</i> was most important as this was the main objective of the urban drainage. The whole infrastructure is designed to secure a good chemical state. Lately there has also been a focus on hydraulic problems, which were considered in some practical Swiss recommendations as the GEP. He personally set the focus on the objective <i>Chemical state</i> when he had to decide.	SH7: method; uncertainty
	SH9: 1. <i>Hydraulic impacts</i> \sim <i>Chemical state</i> 2. <i>Chemical state</i> \succ <i>Hydraulic impacts</i>	SH9: This represents a general gray area of decision that can be evaluated differently. The objective <i>Chemical state</i> represents a more chronic exposure and the objective <i>Hydraulic impacts</i> is rather a pulse load occurring through heavy rain events; this could not be avoided, but could be adjusted depending on the location.	SH9: uncertainty

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
Groundwater	<p>SH9:</p> <ol style="list-style-type: none"> 1. <i>Sewer exfil. ~ Infiltration exfil.</i> 2. <i>Sewer exfil. > Infiltration exfil.</i> <p>SH10:</p> <ol style="list-style-type: none"> 1. <i>Sewer exfil. ~ Infiltration exfil.</i> 2. <i>Sewer exfil. > Infiltration exfil.</i> 	<p>SH9: In the second interview he placed a focus on the pathogens to evaluate the objectives. Currently, there are changes in the legislation and discussions regarding discharge of effluents into water bodies. Herby, pathogens remain in the wastewater and are discharged, despite treating the wastewater. Depending on the region and soil type (karst), this could lead to major problems for drinking water supply.</p> <p>SH10: She was not sure about the consequences of biocides. Questions in the second interview emphasized the worst cases but the first interview made her think more about the status quo. Due to climate change, there might be more separate rainwater/ wastewater systems and therefore the treatment of biocides and filtration would be more important. But in the case when nutrients are on the worst level, one should primarily focus on nutrients.</p>	SH9: different strategies; external influence
Efficiency	<p>SH2:</p> <ol style="list-style-type: none"> 1. <i>Nutrient Recovery > Energy efficiency</i> 2. <i>Energy efficiency > Nutrient Recovery</i> 	<p>SH2: It could be that he considered the topic of phosphorus from a broader perspective or with a different understanding.</p>	SH2: different strategies

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH3:	<ol style="list-style-type: none"> 1. <i>Nutrient Recovery ~ Energy efficiency</i> 2. <i>Energy efficiency > Nutrient Recovery</i> 	SH3: He suspected that these two objectives were less important to him, especially regarding the relevance of phosphorus in Switzerland. In the mean time, he found out that the phosphorus requirements in Switzerland were rather low and mainly used for fertilization in agriculture, in which other substances were used as well. Energy was more important to him, but not extremely more important. SH4: It could be that he considered the specific case study area less strongly in the second interview. He often referred to the general region of Zürcher Oberland when answering questions and thinking about the current energy discussions.	SH3: learning effect
SH10:	<ol style="list-style-type: none"> 1. <i>Nutrient Recovery > Energy efficiency</i> 2. <i>Energy efficiency > Nutrient Recovery</i> 	SH10: She was an expert on recovery of phosphorus. The idea was to reduce nuclear power, but the whole discussion was not clear and she was quite unsure.	SH10: uncertainty
Protection	SH2: <ol style="list-style-type: none"> 1. <i>Surface Water ~ Ground Water > Efficiency</i> 2. <i>Ground Water > Surface Water > Efficiency</i> 	SH2: In the second interview, he weighed groundwater higher than surface water. He could imagine this change due to the current discussion about the “Oberland motorway” (politically debated motorway to be built in the region). If this highway would be built it would affect the groundwater and therefore the drinking water sector in his community.	SH2: external influence

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH6:		SH6: He explained that the change was due to a dependency of the objectives. Generally he thought that both objectives (<i>Surface Water</i> and <i>Ground Water</i>) were important and due to his profession he weighed <i>Surface Water</i> higher than <i>Ground Water</i> , hereby also considering a possible long-term effect that surface water had on ground water.	SH6: different strategies
Hygiene	1. <i>Surface Water</i> ~ <i>Ground Water</i> > <i>Efficiency</i> 2. <i>Surface Water</i> > <i>Ground Water</i> > <i>Efficiency</i>	SH1: He could imagine that the differences might be due to his approach. In the first interview, he considered more the general Swiss level and in the second interview he considered the case study region stronger. There were pipe failures recently in his community. He also considered the status quo which showed that in Switzerland the system was designed for very bad cases by a securely (over) dimensioned system. SH3: It was difficult to decide, maybe because it was not really a problem in Switzerland. He found today's answers more reliable, when referring to the case study.	SH1: different strategies; external influence SH3: uncertainty
	1. <i>Drainage capacity</i> <i>Structural failures</i> 2. <i>Structural failures</i> <i>Drainage capacity</i>	SH3: 1. <i>Drainage capacity</i> <i>Structural failures</i> 2. <i>Structural failures</i> <i>Drainage capacity</i>	
	1. <i>Drainage capacity</i> <i>Structural failures</i> 2. <i>Structural failures</i> <i>Drainage capacity</i>	SH5: It could be that he chose a different approach. His focus in the second interview was more on the possible negative consequences for humans. It was too hard to decide, as the alternatives offered are every extreme.	SH5: different strategies; method

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH7:	1. <i>Drainage capacity</i> ~ Structural failures 2. <i>Structural failures</i> \succ <i>Drainage capacity</i>	SH7: He weighed the structural issues higher in the second interview based on the elaboration of possible consequences in case of an incident and the probability of such an event. He thought structural issues were more difficult to solve than single flooded cellars. He thought that such extreme flooding events were less frequent.	SH7: different strategies; learning effect
Safe wastewater disposal	SH1: 1. <i>Hygiene</i> \succ <i>High reliability</i> 2. <i>High reliability</i> \succ <i>Hygiene</i>	SH1: He assumed a different approach of thinking. Both were important and strongly interrelated.	SH1: different strategies
Social acceptance	SH4: 1. <i>Hygiene</i> \succ <i>High reliability</i> 2. <i>High reliability</i> \succ <i>Hygiene</i>	SH4: He explained the change with an indirect dependency of both objectives. Generally he valued the objective <i>Hygiene</i> higher , but saw an indirect influence of the objective <i>High reliability</i> on the objective <i>Hygiene</i> .	SH4: different strategies
	SH2: 1. <i>Co-determination</i> \succ <i>EFQM-model</i> ~ <i>Time demand</i> ~ <i>Area demand</i> ~ <i>Unnecessary work</i> 2. <i>Co-determination</i> \succ <i>EFQM-model</i> \succ <i>Unnecessary work</i> \succ <i>Area demand</i> \succ <i>Time demand</i>	SH2: He considered the interdependencies of objectives in the second interview.	SH2: different strategies

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH5:	<p>1. <i>EFQM-model</i> ~ <i>Un-necessary work</i> \succ <i>Time demand</i> \succ <i>Co-determination</i> \succ <i>Area demand</i></p> <p>2. <i>Time demand</i> \succ <i>Co-determination</i> \succ <i>EFQM-model</i> \succ <i>Area demand</i> \succ <i>Unnecessary work</i></p>	SH5: He preferred the ranking in the second interview. As explanation he thought it could be the way we asked questions.	SH5: method
Low costs	SH3: <p>1. <i>costcap</i> \sim <i>costchange</i></p> <p>2. <i>costcap</i> \succ <i>costchange</i></p>	SH3: The differences can probably be explained by a more politically-oriented thinking.	SH3: different strategies
Sustainable wastewater infrastructure	SH1: <p>1. <i>Equity</i> \succ <i>Protection</i> \sim <i>Safe WW disposal</i> \succ <i>Low costs</i> \succ <i>Social acceptance</i></p> <p>2. <i>Equity</i> \succ <i>Protection</i> \succ <i>Safe WW disposal</i> \succ <i>Low costs</i> \succ <i>Social acceptance</i></p>	SH1: He generally agreed with both results and thought the weightings were similar.	

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH2:		SH2: Because of a recent highway project in his community, he found the objective <i>social acceptance</i> most important. It was the baseline for the achievement of other objectives. He explained the changes with his more elaborate thinking and consideration of interdependencies when answering the questions. He could imagine that there was a certain learning effect, simply by working through one topic the second time.	SH2: external influence; different strategies; learning effect
SH3:	<ol style="list-style-type: none"> 1. <i>Protection</i> \succ <i>Safe WW disposal</i> \succ <i>Social acceptance</i> \succ <i>Equity</i> \succ <i>Social acceptance</i> 2. <i>Protection</i> \succ <i>Social acceptance</i> \succ <i>Equity</i> \succ <i>Safe WW disposal</i> \succ <i>Low costs</i> 	SH3: He explained the differences by thinking about possible consequences in the second interview, the information, the visualization, the method, and also a learning effect.	SH3: different strategies; method; learning effect
SH4:	<ol style="list-style-type: none"> 1. <i>Safe WW disposal</i> \succ <i>Equity</i> \succ <i>Protection</i> \succ <i>Low costs</i> \succ <i>Social acceptance</i> 2. <i>Protection</i> \succ <i>Safe WW disposal</i> \succ <i>Equity</i> \succ <i>Low costs</i> \succ <i>Social acceptance</i> 	SH4: The reason for changed weighting of the costs, could be a current budget problem for another project. Method and information presentation may play a role to the changes of preferences. There was also learning effect.	SH4: external influence; method; learning effect

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH5:	<ol style="list-style-type: none"> 1. <i>Safe WW disposal</i> > <i>Protection</i> > <i>Equity</i> > <i>Low costs</i> > <i>Social acceptance</i> 2. <i>Safe WW disposal</i> > <i>Protection</i> > <i>Social acceptance</i> > <i>Low costs</i> > <i>Equity</i> 	SH5: In areas where there was uncertainty in the first interview, he was probably still uncertain in the second interview. There was a learning effect because he had thought about the problem twice.	SH5: uncertainty; learning effect
SH6:		SH6: Very similar results.	

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
SH7:		SH7: If someone was asked to decide for a difficult decision situation, the method in the second interview could be a good way to help finding the right option in the right speed and the right way.	SH7: method
	<ol style="list-style-type: none"> 1. <i>Safe WW disposal</i> ~ <i>Protection</i> > <i>Low costs</i> > <i>Social acceptance</i> ~ <i>Equity</i> 2. <i>Safe WW disposal</i> > <i>Protection</i> > <i>Low costs</i> > <i>Social acceptance</i> > <i>Equity</i> 	SH8: SH8: He was positively surprised about the similar answers from the first to the second interview.	SH9: different strategies; method
SH9:	<ol style="list-style-type: none"> 1. <i>Protection</i> ~ <i>Safe WW disposal</i> > <i>Equity</i> > <i>Social acceptance</i> > <i>Low costs</i> 2. <i>Protection</i> > <i>Safe WW disposal</i> > <i>Equity</i> > <i>Low costs</i> > <i>Social acceptance</i> 	SH9: He was surprised by large differences. The objectives are partially interconnected. And often, objectives and means to achieve these objectives were compared with each other, which was a contradiction for him. In such situations, he always weighed the objective higher. In the second Interview, there was a better differentiation.	SH9: different strategies; method

Table SM-8: continued

Objectives	Preferences instability	Explanation	Category
	SH10: No changes in the ranking of main objectives.	SH10: If changes in other objectives occurred, it was because she did not know a lot about some topics, therefore the opinion might be instable and she might have gained more insight.	SH10: uncertainty; learning effect

6. Comparing two different elicitation methods

Table SM-9: Comparison of the two elicitation methods by stakeholders (SH). We present the stakeholders' perception and feedback about the two methods, i.e. the first interview, where we applied an aggregation elicitation approach (using the SMART/SWING-variant to elicit weights and the bi-section method or rough elicitation to determine the shape of the marginal value functions) and the second interview where we used a disaggregation approach, based on UTA GMS. The stakeholders were asked to compare freely the two interviews, then to decide which was easier.

	Statements	Which is easier?
SH1	He found the second interview a bit easier than the first. The reason was mainly attributed to his difficulty in answering the online questionnaire. He believed that a personal interaction would lead to more reliable answers, as one could discuss certain unclear aspects. The comparisons themselves were difficult in both interviews.	The second
SH2	For him, the first and second interview were similarly difficult. The comparisons of alternatives themselves were difficult in both interviews.	Similar
SH3	He thought that the second interview was easier than the first. He understood the way of asking, the method, and topic much better. However, this was due to more knowledge. He felt that he had more knowledge in the second interview, as he had lately discussed this topic more often. The way the questions were asked in the second interview was easier than in the first interview. Especially the online questionnaire was difficult for him.	The second
SH4	The second interview was easier than the first, because the questions were more direct. He also found the way of asking in the second interview shorter. The first interview was more detailed. There was not enough information in the second interview but this was ok, since it was based on the first. As summary the second interview was both easier and more direct.	The second

Table SM-9: continued

	Statements	Which is easier?
SH5	The second interview was easier and more enjoyable than the first. The relation and context of the questions now were now understandable, probably because they seemed more familiar and therefore easier.	The second
SH6	The first interview was less difficult when it came to making decisions. There was less cognitive load in the first interview and the answers were more spontaneous. The way the questions were asked and the related cognitive load was higher in the second interview and therefore the answers were less spontaneous. He had no preference for the two methods, as the results were very similar (main objectives).	The first
SH7	The second interview was easier than the first. In the second interview he already had the relevant information, which he had acquired during the first interview. Moreover, he had to choose between hypothetical and very unrealistic alternatives in the second interview. The method in the second interview was better regarding unclear decisions. If someone was asked to make difficult decisions, the pairwise comparison could be a good way to help them finding the right option in the right speed and the right way.	The second
SH8	The first interview was methodologically more difficult than the second. But from a decision point of view, the second interview was more difficult than the first. The questions and the comparisons themselves could be the reasons for the difficulties in the second interview. The second interview went faster. He often felt insecure in the second interview when making a decision. If he had known that the results concerning the main objectives were as similar in both interviews as they actually turned out to be, he would prefer the second interview to the first because it was faster.	Depends
SH9	There was no difference between the two interviews regarding difficulty. In the second interview, there was a better differentiation between important objectives.	Similar
SH10	The second interview was easier, because there was no elicitation of marginal value functions. The comparisons themselves were difficult in both interviews. Due to the fact that she was able to work through the topic twice (online and interview), the first interview seemed a bit more reliable (more information). However, the preference for one of the two interviews was not very strong.	The second

7. References

- Beinat, E., 1997. Value functions for environmental management. Springer.
- Lienert, J., Scholten, L., Egger, C., Maurer, M., 2015. Structured decision-making for sustainable water infrastructure planning and four future scenarios. *EURO Journal on Decision Processes* 3, 107–140. doi:10.1007/s40070-014-0030-0.
- Zheng, J., Egger, C., Lienert, J., 2016. A scenario-based MCDA framework for wastewater infrastructure planning under uncertainty. *Journal of Environmental Management* 183, 895–908. doi:10.1016/j.jenvman.2016.09.027.