Aspects of Decision Support in Water Management: Data based evaluation compared with expectations

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Abstract

In the cities of Berlin and Potsdam nine water management strategies (scenarios) were evaluated with respect to their ecological effects to the system of surface water. Scenarios were generated by combining different water management measures such as wastewater and storm water treatment. Indicators were qualitatively modelled as well as quantitatively evaluated by experts' knowledge. For decision support Hasse Diagram Technique (HDT) was used. The scenario modular structure increases the transparency of the evaluation process and brought up the question whether time and work consuming calculation of data by mathematical models is needed or experts' knowledge is sufficient for evaluation. To clarify this question, the results of two evaluation examples were compared: (a) data based and (b) experts expectations. Beyond the concept of antagonistic indicators the similarity-profile is introduces as a new tool to compare HDT evaluation results. Our study revealed that in the present investigation evaluation by expert knowledge is not satisfactory. The shift in the type of indicators from state to pressure and the effect of up scaling from local to regional may be the reason.

Introduction

In a research project about sustainable water management in the cities of Berlin and Potsdam (Germany), an interdisciplinary working group, including ecologists, landscape architects and civil engineers developed a framework to evaluate water management strategies (Steinberg et al. 2002, Weigert & Steinberg 2002). As an evaluation tool the Hasse Diagram Technique (Halfon & Reggiani 1986, Brüggemann et al. 2001 and 2003) was applied. Altogether nine water management strategies (scenarios) were evaluated with respect to their ecological effects to the system of surface water. The scenarios are considered of being composed of different modules describing measures for (A) hydrological boundary conditions, (B) waste water treatment, and (C) management of storm water. The modular structuring of scenarios follows the idea of Saaty (1994) to handle complex problems by dividing them into smaller, manageable compartments. While progressing the evaluation process, however, in our research project an unexpected side effect occurs. Members of the working group start arguing about being able to predict the evaluation result, even without using any modelled data. One reason was the modular structure of the scenarios, by which the transparency of the evaluation problem is increased and by which the impression might be given to know already which scenario will be the best.

To clarify the question whether indicator values based on calculated data by mathematical models are needed or solely knowledge of experts is sufficient to evaluate our water management strategies, we analyzed the results of both approaches, the data based evaluation and the evaluation by expert knowledge. The question about the need of modelled data is closely related to two topics, which are of general importance in every decision process: the efficient use of project resources - data modelling is time and work consuming - and the acceptance of the evaluation result. Stakeholders will hardly approve results, which distinctly disagree with their expectations (Lahdelma et al. 2000). The comparison of the evaluation result based on data calculated by the model MONERIS (Behrendt et al. 1999 and 2002) with the evaluation result based on data representing the experts' expectations was carried out by the HDT originated tools of antagonistic indicators and by a similarity-profile. The similarity-profile we introduce as a new approach to compare the evaluation results, namely the structures of Hasse Diagrams (HD) in a detailed and objective way.

Methods

Research Area

Object of research is the complex surface water system of the cities of Berlin and Potsdam (Fig. 1). To evaluate the ecological effects of the water management strategies on the surface waters, not only the evaluation of each indicator representing a certain scenario characteristic is of interest, but also where these patterns appear. Thus, to detect local effects of the scenarios, the water system has been split into 14 sections, each of which contributes its own characteristics to the decision procedure.

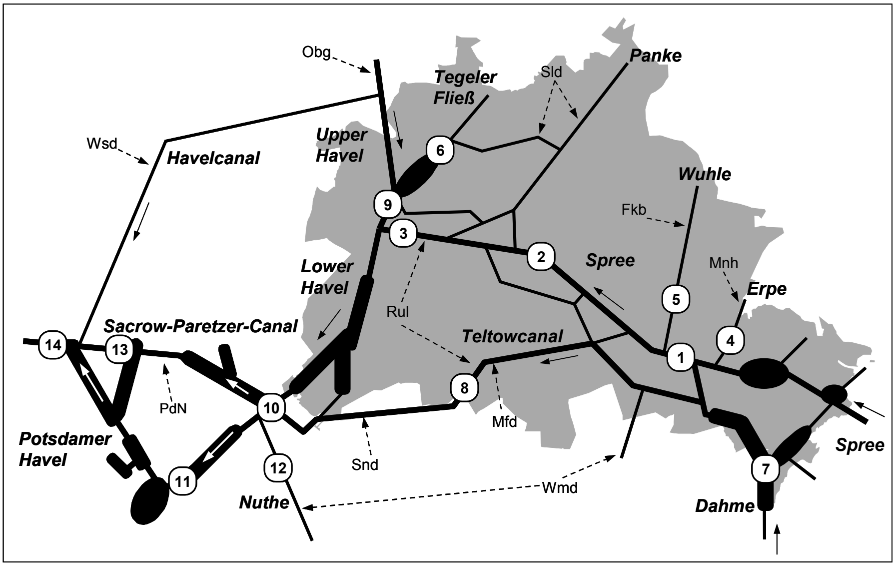

Fig. 1. Schematic diagram of the surface water system of Berlin and Potsdam. River sections: (1) Spree Köpenick (including Dahme), (2) Spree Mühlendamm, (3) Spree Sophienwerder, (4) Erpe (Neuenhagener Mühlenfließ), (5) Wuhle, (6) Inflow to lake Tegeler See, (7) Dahme Schmöckwitz, (8) Teltowkanal, (9) Upper Havel, (10) Lower Havel, (11) Havel Caputh, (12) Nuthe Babelsberg, (13) Sacrow-Paretzer-Kanal, (14) Havel Ketzin. Waste water treatment plants: Obg=Oranienburg, Sld=Schönerlinde, Fkb=Falkenberg, Mnh=Münchehofe, Rul=Ruhleben, Snd=Stahnsdorf, Mfd=Marienfelde, Wmd=Waßmannsdorf, Wsd=Wansdorf, PdN=Potsdam Nord. Dashed lines show wastewater pipe lines. Shaded area = administrative border of the city of Berlin

Water Management Strategies

Altogether, nine water management strategies, 1a, 1, 2, 3, 4, 5, 6i, 6ii and 6iii, in the following called scenarios, were evaluated. Each scenario consists of three modules comprising measures for: (A) hydrological boundary conditions, in particular the amount of water flowing into the area and its nutrient concentrations; (B) wastewater treatment, including the technical equipment of the wastewater treatment plants (wwtp), as well as the spatial and quantitative distribution of purified waste water; and (C) quality and quantity of storm water discharge into river section. The current state represented by scenario 1a is the reference for all other scenarios. The measures, belonging to each scenario are summarised in Table 1. A more detailed description can be found in Simon et al. (2004a, 2004b).

Table 1. Water management strategies. Abbreviations of wastewater treatment plant names are given in Fig. 1. Example how to read Table 1: Scenario 2 includes the following measures: Module (A) reduced amount of water flowing towards Berlin, carrying same nutrient concentration as in the current state. Module (B) technical upgrade of all operating wwtps. Three Wwtps, namely Falkenberg (Fkb), Marienfelde (Mfd) and Oranienburg (Obg) are assumed to be shut down. Module (C) current state of storm water discharge into the surface waters

Abbr. of scenarios	Measures of module (A): hydrological boundary conditions	Measures of module (B): wastewater treatment		Measures of module (C): entry of storm water
		Purification technique	shut down of wwtps	
1a	current state (average of the years 1993-1997)			
1	reduced amount of water			
2		technical upgrade	Fkb, Mfd, Obg	
3	reduced amount of water and lower nutrient concentrations	advanced waste water treatment (micro-filtration)		emission 50% reduced
4			Mfd, Odg	
5			Fkb, Mfd, Obg	
6i		alternative sanitary technique		
6ii			Mfd, Obg, Mnh, Snd	
6iii			Mfd, Obg, Mnh, Sld	

Indicators of data based evaluation

In the first example, the data based evaluation, the nine scenarios (Table 1) are characterised by a set of four indicators. For better recognition the „dat" subscript is added to the indicator abbreviations:

Q_{dat}: Reduction of the discharge in river sections
P_{dat}: Difference of phosphorus concentration from target concentration
N_{dat}: Concentration of total nitrogen
S_{dat}: Short-term pollution of surface waters by storm water

Each of these indicators gets numerical values separately for the 14 river sections. The Q_{dat}, P_{dat} and N_{dat} indicators have been calculated with the model MONERIS, which is described in (Behrendt et al. 1999 and 2002). These indicators are metric quantities. Although the quantitative calculation of the S_{dat} indicator values is included in the MONERIS modelling, the S_{dat} indicator is evaluated qualitatively. The reason is that quantitative effects turned out to be not significant within the uncertainty of the model. The S_{dat} indicator is evaluated best, if there is no direct influence of the river sections by storm waters at all. The reduction of emissions by storm water events of about 50% (SenSUR 1999) is evaluated middle and the present state is evaluated worse. Thus the S_{dat} indicator is considered as an ordinal quantity. The simultaneous consideration of quantities of different scaling levels (metric together with ordinal ones) is one of the core advantages of HDT. Note, that for consistent orientation of indicators, here high values always represent a bad evaluation. Consequently, a high value in one of the measures implies automatically a rather high rank (bad evaluation). As each of the 14 river sections is evaluated separately, a large matrix of 9 scenarios multiplied by 4 indicators multiplied by 14 river sections equals 504 entries is obtained, which we would like to introduce as the data based evaluation matrix.

Indicators of evaluation by experts' knowledge

The modular structure of the scenarios as described in section Water Management Strategies facilitates to predict the ecological effects of the measures within each module, at least as an ordinal quantity. Therefore, an evaluation solely based on the knowledge of experts, here by members of the project group, becomes possible. To transform the experts' expectations into a data matrix, indicators for qualitative evaluation of the measures within each module are defined (see below). For consistent comparison of evaluation results, high indicator values again represent a bad evaluation. Note, that interactions among measures cannot be considered. Indicators representing the experts' expectations are labelled with the „exp" index. The indicator values defined by members of our project group are shown in Table 2.

Indicators to evaluate measures of module (A): Hydrological boundary conditions:

Ha_{exp}: Amount of water entering the research area. The indicator is evaluated in two classes. A good evaluation of the present state (indicator value 0) and a worse evaluation in case of scenarios 1 to 6iii, comprising a reduced amount of water entering Berlin (indicator value 1).

Hq_{exp}: Quality of water entering the research area. Scenarios 1a, 1 and 2 represent the present state and got a bad evaluation (indicator value 1), whereas the scenarios 3 to 6iii are evaluated better (indicator value 0) because of lower nutrient concentration due to an improved technical standard of wwtps in the catchments area upstream of Berlin.

Table 2. Evaluation matrix based on expectations. High values are representing a bad evaluation

Indicator/ Scenario	P_{exp}	N_{exp}	S_{exp}	Ha_{exp}	Hq_{exp}
1a	2	2	1	0	1
1	2	2	1	1	1
2	1	2	1	1	1
3	0	1	0	1	0
4	0	1	0	1	0
5	0	1	0	1	0
6i	0	0	0	1	0
6ii	0	0	0	1	0
6iii	0	0	0	1	0

Indicators to evaluate measures of module (B): waste water treatment:

P_{exp}: phosphorus emission of the wwtps. Scenarios 1a, and 1 get the highest indicator value (2), representing the worse evaluation. Scenario 2 comprises technically upgraded wwtps with a reduction of phosphorus emissions. Consequently it is given the indicator value 1. Scenarios 3 to 6iii are evaluated best (indicator value 0). Advanced wastewater treatment and alternative sanitary technique will reduce phosphorus emissions of the plants significantly.

N_{exp}: nitrogen emission of the wwtps. Scenarios 1a, 1 and 2 are evaluated equivalently worse (indicator value 2). Scenarios 3 to 5 assuming technical upgrade of all wwtps is evaluated middle (indicator value 1). Scenarios suggesting alternative sanitation technique (6i to 6iii) are evaluated best (indicator value 0). Due to separation of urine and faeces, the discharge of nitrogen into the surface water will be drastically reduced.

Indicators to evaluate measures of module (C): short term pollution of surface waters by storm water

$\mathbf{S_{exp}}$: A bad evaluation (indicator value 1) is given to scenarios 1a, 1 and 2, representing the present state. Scenarios 3 to 6iii are evaluated better (indicator value 0), as storm water events are reduced for about 50%, according to the Sewage Disposal Plan (SenSUR 1999).

Hasse Diagram Technique and the concept of antagonistic indicators

The Hasse Diagram Technique (HDT) is a method to sort options (here scenarios) evaluative with respect to all indicator values simultaneously, however without aggregation of indicators. The HDT evaluation is based on a simple ≤ comparison of the options indicator values within every single indicator. For consistent evaluation, all indicator values have to be oriented uniformly: for instance, high values always have to represent a bad evaluation. More technical details can be found for example in Brüggemann and Carlsen, p. 61 and in references Halfon & Reggiani (1986), Brüggemann et al. (2001, 2003) and Brüggemann and Drescher-Kaden (2003). The evaluation result is depicted in a so-called Hasse Diagram (HD). Connective vertical lines show that the indicator values of the options will simultaneously increase (upwards) or decrease (downwards). Note that the evaluation of options is only deduced following exactly one vertical direction. Options not being connected with a sequence of vertical lines are not comparable with each other because of antagonistic indicators. For explanation let us consider two incomparable objects: There is at least one pair of indicators in which one indicator is better evaluated with respect to one option and worse in the other. The other indicator is evaluated in the reverse sense. Thus the incomparability among objects indicates differences in their profile of characteristic properties and can be analysed by the HDT-originated tool of antagonistic indicators, which formalizes the set of advantages and disadvantages with respect to each indicator. Note, that more than two indicators can be necessary to explain the complete separation of any of two objects or group of objects. The reason is possible overlapping of the antagonistic indicator intervals. Overlapping indicator intervals can explain the incomparability among objects only to a certain percentage. Consequently, more than two antagonistic indicators are needed to explain total separation of objects (Simon 2003).

By automated identification of antagonistic indicators with the WHASSE software, immanent conflicts in the evaluation matrix can be discovered in a convenient way, and thus the advantages and disadvantages of each option under discussion can be named. The precise knowledge about antagonisms supports the stakeholders' decision process as further discussions can focus on these immanent evaluation conflicts. The methodologically strategy how to solve these conflicts is one of the most crucial steps of the evaluation process (Strassert 1995).

Similarity of Hasse Diagrams

Similarity indices are well known in statistical literature and also discussed in this book by Pavan et al., p. 181, especially their S(E,M)-index. Mostly similarity indices, however only provide highly aggregated information, and for that reason they imply a lost of information. For detailed comparison of HDT results, visualized by Hasse Diagrams (HD), we introduce a new tool, the similarity-profile. By the similarity-profile the structural accordance and discordance between any two HDs can be described in detail. As explained in the chapter by El-Basil, p. 3 and in chapter Brüggemann and Carlsen, p. 61, Hasse Diagrams are graph theoretical structures. Therefore the comparison of evaluation results is not only to relate one object to other ones, but also to investigate the graph as a whole. In that sense we are speaking of a structure of an evaluation result.

Our similarity-profile is adapted from an approach proposed by Sørensen et al. (2004), see also the more general discussion about correlation in chapter by Sørensen et al., p. 259. The relation of each option to another one is written down in a matrix, separately for both diagrams. Altogether four possible relations can occur:

- $>$ scenario x is evaluated better than scenario y.
- $<$ scenario x is evaluated worse than scenario y.
- $\sim$ scenario x is equivalent to scenario y and
- $||$ scenario x is incomparable to scenario y.

Consequently, maximal 16 combinations of relations can be found if two diagrams are compared with each other. The similarity-profile however describes four different kind of relations:

(1) Parallel relations of options in both diagrams, such as < <, > > and ~ ~. E.g., the parallel relation < < means that scenario x < scenario y in HD_1, and scenario x < scenario y in HD_2. Parallel order relations indicate a similar ranking of options in the two compared Hasse Diagrams and thus there is no evaluation conflict.
(2) Indifferent relations of options in both diagrams, such as > ~, < ~, and ~ >, ~ <. While in one Hasse Diagram the options are evaluated equivalent, in the other Hasse Diagram the options are ranked. Thus „indifferent“ shows a difference in the evaluation, but not a conflict as strong as „anti-parallel“.
(3) Anti-parallel relations of options in both diagrams, such as < > and < >. They show contrary rankings of options in two Hasse Diagrams, and thus discover a strong evaluation conflict.
(4) Uncertain relations of options in both diagrams arise, when an option is incomparable to others in at least one of the diagrams. Uncertainty includes: || <, || >, || ~, || || and < ||, > ||, ~ ||. To generate an incomparability, there must be at least one pair of antagonistic indicators. For that reason „uncertainty“ expresses also a strong conflict of the compared evaluation results.

The similarity-profile can be generated by counting all relations of each of the four groups and can be visualized by a bar plot.

Evaluation Results

The Hasse Diagrams, visualising the results of the two evaluation examples are shown in Fig. 2. By the data based evaluation (Fig. 2, left diagram) the three scenarios 4, 6i and 6ii are identified as favourable, whereas by expectations of experts (Fig. 2, right diagram) four scenarios results as best possible solutions. These are 1a, 6i, 6ii and 6iii. However the scenarios 6i, 6ii and 6iii are equivalent, i.e. they have got an identical evaluation in all indicators. The incomparability between the winner scenarios within each evaluation example can be explained by analysing the antagonistic indicators, revealing the advantages and disadvantages of each scenario (Fig. 3, left hand side). In case of the data based evaluation two reasons were identified to cause the incomparability: (1) thematic antagonisms occur because different indicators such as phosphorus concentration (P_{dat}) and discharge reduction (Q_{dat}) are involved. And (2) spatial antagonisms, as different river sections such as the tributaries Erpe (section no. 4) and Wuhle (section no. 5) are affected. In contrast, in the evaluation based on experts expectations incomparability is only caused by thematic antagonisms: The higher amount of water entering the research area (Ha_{exp}) is identified of being the only advantage of scenario 1a, whereas the four indicators phosphorus (P_{exp}), nitrogen (N_{exp}), short term pollution (S_{exp}) and the quality of water entering the research area (Hq_{exp}) are evaluated better in the scenarios 6i, 6ii and 6iii (Fig. 3, right hand side).

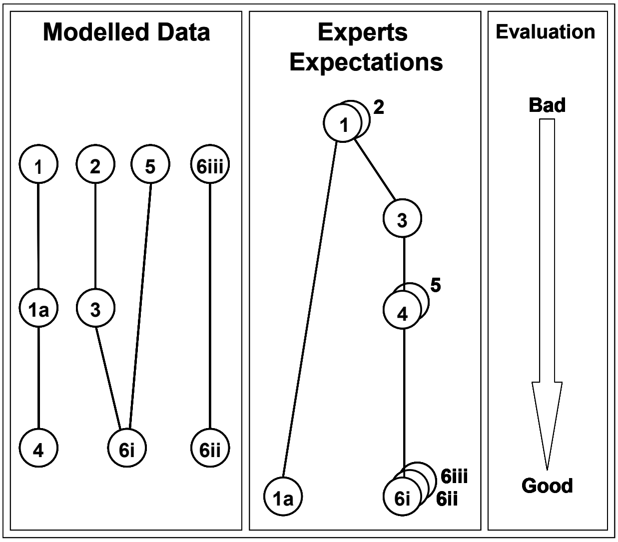

Fig. 2. Results of the two evaluation examples. Circles symbolize scenarios. For description of scenario abbreviations see Table 1. Segments of circles symbolize equivalent evaluation of scenarios. Left diagram: result based on modelled data. Right diagram: result based on experts knowledge

Beyond differences between both evaluation examples concerning the scenarios, which are evaluated, the best, optical inspection of both Hasse Diagrams reveals further obvious dissimilarities. These structural differences can be described in more detail and objectivity by the similarity-profile (Fig. 4). When the structure of both HD's are compared, only few parallel relations (about 17%) can be found, indicating total agreement in the evaluation of scenarios in both evaluation examples. There are also only few indifferent relations (about 2.7%), showing differences in the evaluation of scenarios: while in one HD the scenarios are ranked, they are evaluated equivalent in the other HD. Indifferent relations can be addressed to the evaluation result based on experts knowledge (Fig. 2, left diagram). There are no anti-parallel relations, which would indicate severe evaluation conflicts because of converse ranking of options in both HD's. However, there is a clear dominance of uncertainties (about 80%), discovering severe disagreements in how the scenarios are ranked in both evaluation examples. This high amount of uncertainties is caused by incomparability among scenarios and can be addressed to the existence of three hierarchies in the databased Hasse Diagram. These differences, however, need to be traced back in more detail. They discover conflicts between modelled data and experts expectation and therefore they will reduce the acceptance of the evaluation result.

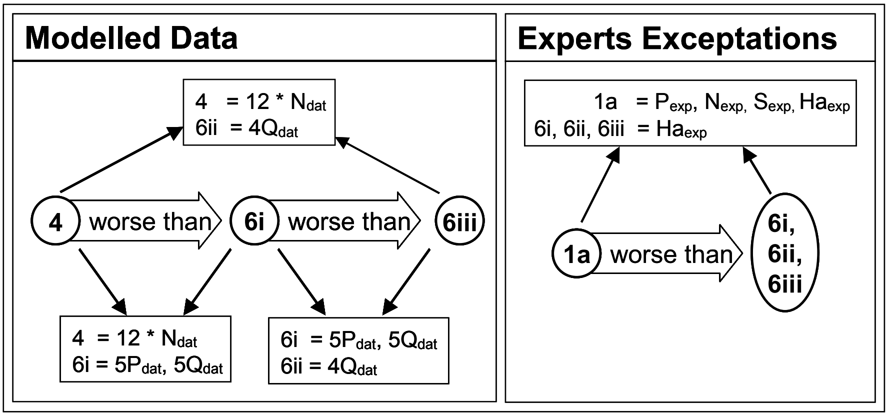

Fig. 3. Antagonistic indicators of favourable scenarios. Note that here only the better-evaluated indicators of the antagonisms are given. They represent the advantage of one of the two incomparable options, which implies to be the disadvantage of the other one. An example how to read the graphic: In the first evaluation example scenario 6ii is incomparable to 6i (||), because in 6ii the indicators phosphorus load and discharge reduction, both concerning the river section Wuhle ($5P_{loc}$, $5Q_{loc}$) are evaluated better than in 6i. In contrast, in 6i the indicator discharge reduction concerning the river section Erpe ($4Q_{loc}$) is evaluated better than in 6ii

Discussion

In our study, the comparison of the evaluation results based on modelled data and based on experts expectations, prove the need to calculate data by a mathematical model to obtain sufficiently detailed and precise results. The insufficiency of evaluation based on expectations can be mainly addressed to two topics: (1) A shift in the type of indicators from pressure to state and (2) a shift in the geographical scale from local to regional.

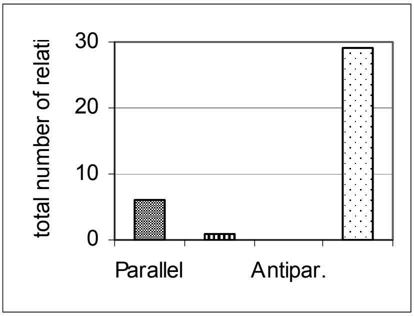

Fig. 4. Similarity-profile of the evaluation examples

According to the P-S-R-approach of the OECD, indicators can be classified into three basic groups (OECD 1994): Pressure indicators (P) are describing the causing factors such as emissions of technical assets. State indicators (S) represent the present state, for example the trophic state of an aquatic ecosystems. Response indicators (R) are mapping reactions of the society to a certain problem. In our case study, all the data input by experts' knowledge can be characterized as pressure indicators. For example: indicators characterizing the impact of waste water treatment plants on the surface waters, only provide information about emission of phosphorus and nitrogen and the amount of waste water which is discharged into river sections. In contrast, by using the model MONERIS, the final nutrient concentrations and discharges of the river sections are calculated. Thus the original input data representing pressure indicators are transformed into state indicators describing resulting effects. In addition, by the modelling of data the interactions between the original pressure indicators can be implemented. The final nutrient concentration for example, results from multiple sources such as initial level of water pollution and emissions of several different pathways such as wastewater treatment and storm water.

When the evaluation is based on expert knowledge, only pressure indicators can be relevant. Whereas precise information about emissions into the surface waters can be available, the prediction or estimation of the resulting concentrations of substances as well as the final discharge is almost impossible. However, under certain conditions it might be manageable to predict state indicators sufficiently. For example if there is only one source of emission and only one river section. In our case study this for instance was true for the river section Wuhle. Experts with precise local knowledge were able to predict the effects of the shut down of the wwtp Falkenberg precisely, including the resulting degradation of the water quality. If advanced wastewater treatment is assumed, the discharge of sewage from the wwtp into the river Wuhle will actually cause a dilution of the nutrient concentration. However, having more than one source of emission and a complex system of surface water including tributaries, a precise prediction of effects (state indicators) is impossible to derive from pressure indicators alone.

Beyond the type of indicators (pressure-state-respond) also different geographical scales are addressed when data based evaluation is compared with that of experts' knowledge. Data based evaluation can be referenced to a local scale. Thus spatial effects can be detected in more detail, even though the definition of the river sections is determined on the one side by the official monitoring program, surveying the quality and quantity of the flowing waters, and on the other side by the need to observe the influence of tributaries. In contrast, data based on information about emissions (pressure indicators) can be only addressed to the directly affected river sections. Consequently the evaluation will be incomplete with respect to the entire system of surface waters. Alternatively, emissions can be summarily evaluated, which rather equals a regional scale. Thus up scaling is taking place, because as stated before it is not possible to detect spatially differentiated effects by expectations if a large system of surface water is investigated.

The topics discussed above showed that the decision whether effort of time and manpower to model data is legitimated, or experts' expectations are sufficient for evaluation, largely depends on the complexity of the problem. Complexity might be related to the geographical extend of the study, e.g., a complex system of surface water, or might be caused by the variety of influencing variables, such as social or political interests to be represented by indicators. In our study the complexity of a local referenced evaluation required data calculated by a mathematical model. Therefore the effort to model data can be legitimated by the advantage of precise information. Experts' expectations would provide insufficient information to evaluate the effects of water management strategies with respect to the surface water system of the cities of Berlin and Potsdam. The corresponding loss of information is expressed in the similarity-profile high number of uncertainties. In some cases there can be a better efficiency in using project resources such as time, manpower and knowledge, if the evaluation is solely based on experts knowledge. The evaluation of single river sections such as the river Wuhle, which is briefly described above, is an example. As expectations provide sufficient precise results, modelling of data cannot be legitimated by an increase of information. However, the efficiency in using project resources will be not detectable in the similarity index, as both evaluation results, data based and expectations, should be in good agreement.

Between the unambiguous extremes of a total preference of modelled data and expectations respectively, there is a wide range where both approaches increasingly conform with each other with respect to the agreement of their results and efficiency of project resources respectively. However, this range might include that the choice of the method is not adequate to the problem. For example: evaluation on a regional scale is inappropriate to decide about local referenced water management strategies, independently from the methodological question whether modelled data or experts expectations should be the data base. Again, such a spatial inadequacy is not detectable by a tool such as the similarity profile, as data based evaluation as well as expectations both might provide sub-optimal results. The specific problem of finding the adequate scale and method including the generation of a complete set of indicators and a broad variety of options cannot be supported by methodological tools but has to be solved discursive by the stake holders and public respectively. The latter is concerned to the topic of participation (Lahdelma et al. 2000, Munda 2004, De Marchi & Ravetz 2001). Methodological tools such as the similarity-profile, however can help to analyze and to explain discrepancies between experts expectations and modelled data. Mediation between both evaluation results can be important to increase both, transparency and acceptance of decisions.

Conclusions and Prospect

The comparative study of evaluation results based on modelled data and obtained by experts expectations respectively, revealed that in the present investigation the evaluation by expert knowledge is not satisfactory. Even though there are agreements in both results, such as scenarios which are identified as potential winners in both approaches, the dominance of differences (disagreements) prove the need of modelled data to obtain sufficiently detailed and precise results. The insufficiency of evaluation based on expectations can be mainly addressed to two topics: A shift in the type of indicators from pressure to state and a shift in the geographical scale from local to regional.

The modular structure of the water management strategies (scenarios) facilitates to solve the complex problem by split it into manageable parts (Saaty 1994). Consequently transparency is increased as demanded by the "Lokale Agenda". The model MONERIS and the Hasse Diagram Technique respectively support this strategy. MONERIS, which is of modular structure as well, facilitates to adapt the input data to changing conditions such as adding or modification of scenarios. Furthermore in practical application the model is holding excellent balance between generalization and detailed information. HDT is providing convenient tools for data analysis.

It is somehow paradox, that the good transparency supported by modular scenarios gives the impression that expectations will offer sufficient evaluation results, superfluous the need to model data. Anyway, discrepancies between expected and modelled evaluation results need to be removed, as stakeholders will hardly accept an evaluation result, which extensively disagrees with their expectations. HDT-originated analysis tools such as the antagonistic indicators and the similarity profile proved to be helpful in such conflicts. Thus beyond the application of HDT in the field of multicriteria decision aid (MCDA) the approach might be a helpful tool to mediate the whole decision process.

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