QUANTIFYING BENEFITS FOR IMPROVED ENVIRONMENTAL AND WATER QUALITY

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ABSTRACT

In this paper the design of an approach for quantifying the benefits of changes in water quality due to reduced diffuse pollution is discussed. The approach bases on the contingent valuation (CV) which is a scientifically accepted method to quantify positive external effects such as changes in environmental quality. The analysis is an integral part of the REGFLUD project. Relevant information regarding the relationships and effects of lower nutrient concentrations in surface waters is provided by expert interviews and a study of literature. The results of expert interviews strongly determine the design of the standardised questionnaire to be developed. Since water quality has been significantly improved in the past due to reduced pollution from point sources experts see only little scope for further improvements triggered by a reduction of diffuse pollution. Additionally, the actual incidence of these effects is regarded uncertain due to regionally varying conditions. Considering simultaneously these results on the one hand and the prerequisites of an accomplishment of CV on the other hand suggests the use of salmon population as the indicator to describe an environmental change scenario to respondents. Based on this scenario respondents are asked to express their willingness to pay (WTP). WTP enters a cost-benefit evaluation of measures aiming at a reduction of diffuse pollution.

Keywords expert interview, contingent valuation method, diffuse pollution, Water Framework Directive, willingness to pay

INTRODUCTION

The Water Framework Directive (WFD) entered into force in 2000 and constitutes a uniform framework for water protection in the EU. Fundamental objectives of WFD are to attain area wide water protection in all member states and to achieve a good ecological status (good ecological potential) of surface waters and ground water bodies by 2015. An essential impetus for WFD was an increasing demand by citizens and environmental organisations for cleaner rivers and lakes, ground water and coastal beaches (see European Commission, 2003). Hence, the roles of citizens and citizens' groups will be crucial in achieving the determined objectives.

The involvement of experts, citizens, and stake holders is an important issue within the interdisciplinary project "Management of Regional German River Catchments" (REGFLUD)1 that addresses the problem of diffuse pollution of ground and surface waters by agriculture. The overall objective of REGFLUD is the development and application of multi-criteria scientific methods to set up a Decision Support System (DSS) providing information to policy makers with respect to the implementation of WFD. The study area covers two heterogeneous German river catchments i.e. the river Ems basin (12,900 km²) and sub-catchments of the river Rhine basin (Sieg, Wupper, Erft and Ruhr; 12,100 km²).

Experts, citizens, and stake holders participate in different phases of the REGFLUD project. In a first phase expert knowledge is combined with a study of the literature to describe the status quo situation and major problems in the study area. This offers valuable clues to an estimation of benefits that citizens attribute to improvements of water quality which follows in a second phase of the project. In a third phase nutrient reduction strategies are elaborated with stake holders based on a balancing of costs and benefits of various agri-environmental measures. The costs are provided by a model-based analysis (see Kunkel et al., 2003; Goemann et al., 2003).

Regarding the current progression of the REGFLUD project this paper presents the findings of the first phase i.e. the status quo and concludes with implications for the estimation of benefits.

METHODS

Informal expert interviews that are a widely applied and flexible method are used to collect the relevant information regarding the status quo situation, dominant problems within the studied river catchments, and potential impacts of a reduction of diffuse nutrients that are perceivable by citizens. In addition, the experts are asked to what extent the situation and potential impacts of nutrient reductions in the studied river basins can be generalised and applied to other regions. The information is complemented by a study of the literature.

The methodological design to estimate the benefits that citizens attribute to an improvement of water quality depends on the findings of the expert interviews and the study of the literature. In order to draw the readers attention to the intricacy of quantifying benefits the basic features of the approach used in the REGFLUD project are described prior to the

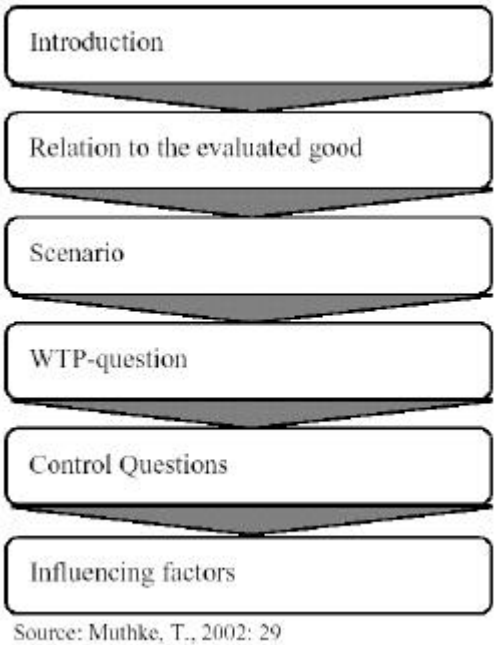
1 Commissioned by the German Ministry for Education and Research.

presentation of the results. The estimation of benefits is based on the contingent valuation method (CVM). In the context of standardised interviews residents are asked about their appreciation for a change in environmental quality.

Basically, two different approaches are distinguished due to the assignment of property rights on the environmental good. In the case property rights belong to the respondent the person is asked about the amount of money she/he would accept as a compensation for a loss of environmental quality. In the other case property rights belong to the polluter respondents are asked about the amount of money they would pay to avert or reducing negative effects on the environmental good. The approaches are called "willingness to accept" (WTA) and "willingness to pay" (WTP), respectively. In general WTP leads to lower amounts of money because respondents answer more cautiously opposed to WTA (Mitchell/ Carson, 1989: 37). Thus, WTP is preferred in most analyses (cp. Mitchell/ Carson, 1989: 196) and is applied in this project.

In contingent valuation (CV) studies several methods of questioning exist. The face-to-face interview - also recommended by the NOAA-panel - is one of the most frequently applied questioning methods. For the purpose of this study the advantages of a face-to-face interview outbalance its disadvantages such as a possible influence of the interviewer and higher costs compared to a telephone or written interview. The key advantages are the controlled conditions while the respondents answer the questions (Carson/ Flores/ Meade, 2000: 180) and the opportunity to use graphic aids and appliances.

CV uses standardised questionnaires that typically follow the structure outlined in Figure 1. After an introduction to the topic various potential relationships of the respondent to the environmental good such as the frequency of utilisation of the good by the respondent are questioned. Previous studies point out the weakness of socio-economics characteristics (e.g. age, sex, education, and income) in explaining the amount of WTP (cp. Enneking, 1998: 182). In response to this findings in a variety of studies respondents are asked about her/his environmental attitude (e.g. a membership of an environmental organization). A detailed, plain, and realistic characterisation of the environmental change scenario providing information about appearance and range is a major requirement for CVstudies. More over, the scenario should offer an incentive for the respondent to reflect the WTPquestion in the sense of providing a scenario that matters to her/him (Mitchell/ Carson, 1989: 214). The scope of interpretation should be as small as possible to improve and guarantee the reliability of the study. Albeit the above mentioned weakness of socio-economic characteristics in explaining WTP they are in general the concluding questions.



Source: Muthke, T., 2002: 29

Figure 1 design of Standardised Questionaire

Further issues being relevant for the design of the standardized questionnaire for CV result from the fact that the survey is conducted just within a sample of selected regions which should represent the whole study area. Thus, the design has to ensure applicability and transferability of WTP from selected regions to the whole study area. The so called Benefit Function Transfer (BFT) requires an econometric analysis of all surveyed sample data. Estimated benefit functions are applied to other regions on the basis of official statistics. Of course, BFT hinges upon the availability of appropriate official data. This reduces the number of factors that can be considered for an area wide WTP analysis. As an example the environmental attitude is surveyed by order of the German Federal Environmental Agency. However, the data is inapplicable for BFT in the REGFLUD project because of the rough regional just differentiation between Old and New Laender.

RESULTS

The results of interviews with experts of various disciplines and a study of the literature give a comprehensive overview about the status quo situation of examined catchments, major problems with respect to the implementation of WFD, and potential noticeable impacts of nutrient reduction measures on environmental quality. Findings differentiated by environmental impacts resulting from water structure, chemical substances and physical impacts are summarised as follows:

1. A major issue within the investigated catchments is the conversion of the water structure. The conversion of natural water structure started in the 15th century with the utilisation of natural river beds for agricultural land and achieved a peak level in the 20th century. The straightening of rivers combined with a trapezium shaping destroyed the natural structure of rivers and small streams (Vereinigung deutscher Gewässerschutz, 2001: 22) which increased the stream velocities. In order to sustain the conversion the banks were reinforced. In consequence, the self purification potential of rivers diminished representing an indirect impact of converting water structure (Vereinigung deutscher Gewässerschutz, 2001: 19 et seq.). More over, the installation of hydroelectric power plants and weirs constrains and may even avert the biological and chemical interchange. Migratory fishes such as salmons are impeded in spawning which is partly eliminated by the installation of fish staircases (Schmidt, 1994: 24). However, the impacts of interrupted exchange of chemical substances on the river bed remain (cp. Wupperverband, 2001: 28). In addition, physical impact such as thermal effects of cooling water inputs substantially change ecological conditions.

2. Chemical pollution has been significantly reduced. Chemical pollution comprises among other substances pesticides, hormonal effective substances, nutrients, and heavy metals which partly relate to the present latent geogenic concentrations in ground water. Experts attach the largest impact on water bodies to toxic and hormonal effective substances. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2001, 48) estimates the input of pesticides into water bodies to approx. 30 tons per year in Germany. Primary polluters are the industry, agriculture and private households who generally apply pesticides in an unprofessional and improper manner. Assessing the development of pesticides in water bodies is difficult. A rising trend in the concentration of pesticides is observed. However, this may partly be due to improved test procedures measuring least concentrations that could not have been detected in the past (Ministry for the Environment of the Federal State of Lower Saxony, 2001: 14). In the last decades nutrient inputs into water bodies have been reduced primarily due to the omission of phosphates in detergents and the upgrading of sewage treatment plants.

3. Diffuse pollution by agriculture still plays an important role. In Germany the prevailing nutrients of diffuse pollution are phosphorus and nitrogen compounds such as phosphate and nitrate respectively and the eco-toxicological compounds ammonium and nitrite. The share of diffuse phosphorus and nitrogen inputs in total nutrient inputs into water bodies amount to approx. 70% and 72% respectively. The agricultural share in total diffuse pollution is estimated at 90% (Vereinigung deutscher Gewässerschutz, 2001: 26). This share increased due to lower reductions of nutrient emissions by agriculture compared to other emission sources. Regarding ecological effects of chemical compounds various aspects such as their biological effectiveness, their seasonal allocation, and their entry paths such as the direct run off or the entry into surface waters via ground water need to be considered.

4. Phosphorus and nitrogen are of particular relevance for the eutrophication of inland waters. Elevated nutrient concentrations in dammed streams and lakes due to agricultural fertilisation may lead to excessive algal blooms followed by a higher turbidity and malodour. Basically, two compounds are distinguished: solved phosphorus with a high bio-availability and phosphorus conjugate to particulate matter with a low bio-availability (Deutscher Verband für Wasserwirtschaft und Kulturbau e.V., 1998: 39). The main part of diffuse phosphorus inputs occurs by erosion off the vegetation period in winter time (Bach, M., Frede, H.-G., 1996: 50). Thus, the bio-availability is low implying a negligible influence on eutrophication of streams. Solved and conjugate phosphorus compounds are interrelated. Lowering the concentration of solved phosphorus would solubilise phosphorus conjugate to particulate matter that accumulated to a considerable extent in the sediment in the past. Because of the relationship a reduction of phosphorus does not result in an immediate limitation of algal blooming. However, depending on the weather a control of the algal blooming may be achieved by reducing the concentration of nitrogen compounds. While impacts are directly perceptible in lakes they are noticeable more remotely in streams and rivers because of the current (cp. Deutscher Verband für Wasserwirtschaft und Kulturbau e.V., 1998: 33).

5. Nitrogen causes problems regarding the drinking water supply. The so called base flow via the ground water is an important path way of nitrogen entering surface waters. In case of excessive nitrogen charges into the ground water the nitrate concentration may exceed the critical value of 50 mg/l given by the Drinking Water Regulation. This requires adequate measures to blend highly polluted water with less polluted water or to use deeper groundwater floors. Anyway, the additional measures imply extra costs for the drinking water companies.

6. Diffuse pollution may change the biodiversity of inland waters. Diffuse nutrient inputs lead to an adjustment of the species spectrum (Frede/Dabbert, 1998: 4). Reducing diffuse pollution would possibly increase the population of certain organisms such as salmons. This is a result of a research project by the university of cologne and the Ministry for the

Environment and Nature Conservation, Agriculture and Consumer Protection of the Federal State of North Rhine-Westphalia (MUNLV). According to the study agricultural diffuse nutrient inputs are one of the potential factors that deteriorate the conditions of natural reproduction by lowering the oxygen available for spawn (MUNLV, 2001: 48).

7. Nutrient charges affect the North and Wadden Sea. Agricultural nutrient emissions in inland waters increase nutrient charges of rivers resulting in higher eutrophication of the North and Wadden Sea (cp. Deutscher Verband für Wasserwirtschaft und Kulturbau e.V., 1998: 43). Possible effects of eutrophication are algal blooms, black spots and black areas, in particular in the Wadden Sea of Lower Saxony. The noticeability of such appearances depends on the coincidence of several conditions such as a certain concentration of nutrients together with weather conditions e.g. luminosity and drift (Lehnhart, H.-J., 1999: 139). The complexity of relations along with high atmospheric nitrogen deposits makes it difficult to isolate and attribute effects of reduced agricultural nutrients (Lehnhart, H.-J., 1999: 38). Further aspects that have to be taken into account are the upgrading of sewage treatment plants and the omission of phosphates in detergents. These developments affect the periodicity, intensity and noticeable effects in the North and Wadden Sea.

DISCUSSION AND CONCLUSIONS

Results of expert interviews and the study of literature are discussed with respect to the design of the standardised questionnaire for CV analysis. The following aspects have to be considered:

Significant improvements of inland water quality in the past that were primarily due to the reduction of pollutants from point sources limit potential impacts of reducing diffuse pollution. More over, the effects of diffuse nutrient inputs on different locations are highly uncertain because of the complex relationships that can vary substantially between water bodies and even between sections of water bodies. Thus, the description of possible and in particular of generally perceivable improvements of water bodies due to reduced nutrient inputs is intricate and might not be fully understood by the respondent. The mostly inferior changes offer little incentives to the respondent for a thorough reflection of her/his WTP. More over, she/he may be mislead to value the appearance of water bodies that is mainly determined by water structure. In this case, a comparison a balancing of WTP with estimated costs of reduced diffuse pollution is not valid. Consequently, using these effects does not seem to be appropriate for a CV-study. The following three example of expectable impacts clarify further intricacies (see figure 2):

A reduction of turbidity and malodour would possibly offer an incentive to the respondent to reflect her/his WTP. This improvement directly increases her/his satisfaction of using the water. However, no commonly known approach describing a change in turbidity or smell of waters exists that is clear to the respondent and would fulfil the requirements of a CV-study. There is a strong disbelieve about respondents abilities to imagine different levels of malodour and visual depths.

A reduction of eutrophication of the North and Wadden Sea could also be of interest. A diminished occurrence of macro algae, algae foam, black spots and black areas could enhance the recreational benefits of residents and vacationers at the North Sea. Nevertheless, the uncertainty of predicting changes and their marginal ranges has to be taken into account. Because of the seasonal occurrence of macro algae and algae foam on the beach as well as black spots and black areas in the Wadden Sea it might happen that even frequent vacationers of the North Sea have never seen any of the described effects. Asking those North Sea users about these impacts would likely give rise to misunderstandings and indignation. Such a situation has to be avoided by all means since responses would lack a scientific basis.

A reestablishment or conservation of natural biodiversity prerequisites knowledge of the respondent about certain species which cannot be generally expected. In addition, marginal increases of the population of some species such as river shells might be of little interest to respondents. Answers on questions concerning the restoration of natural biodiversity may be biased. WTP conforms to the amount of money of which respondents believe that society expects them to pay (Enneking 1998, 164).

Regarding the limited information capacity of respondents in a survey situation the interview and thus the described environmental change scenario has to be as concise as possible. For this reason the most appropriate effect has to be selected. None of the effects discussed above (see also Figure 2) fully complies with the postulated requirements of a CV-study. Above all, there are no generally observable effects that characterise area wide environmental changes. They apply predominantly to single streams or even single stream sections and cannot be easily transferred to an area wide approach pursued in the REGFLUD project.

After comparing advantages and disadvantages of the mentioned impact categories the restoration and conservation of natural biodiversity appears to be appropriate to estimate WTP for an improvement of water quality. Among the species salmon has been chosen in order to provide an incentive to the respondent to reflect her/his WTP. Salmon currently attracts some public awareness because of media reports and a salmon resettlement program in German rivers and rivulets funded by MUNLV. It is expected that the name recognition of salmon offers an incentive to respondents to reflect their WTP so that an essential condition of CV is fulfilled. The fact, that salmon is known as an indicator of water quality may possibly confer additional importance. However, quantifying changes in salmon population due to a reduction of diffuse nutrient inputs is not possible yet resulting in a wide range of interpretation which restricts the analysis to elicit tendencies.

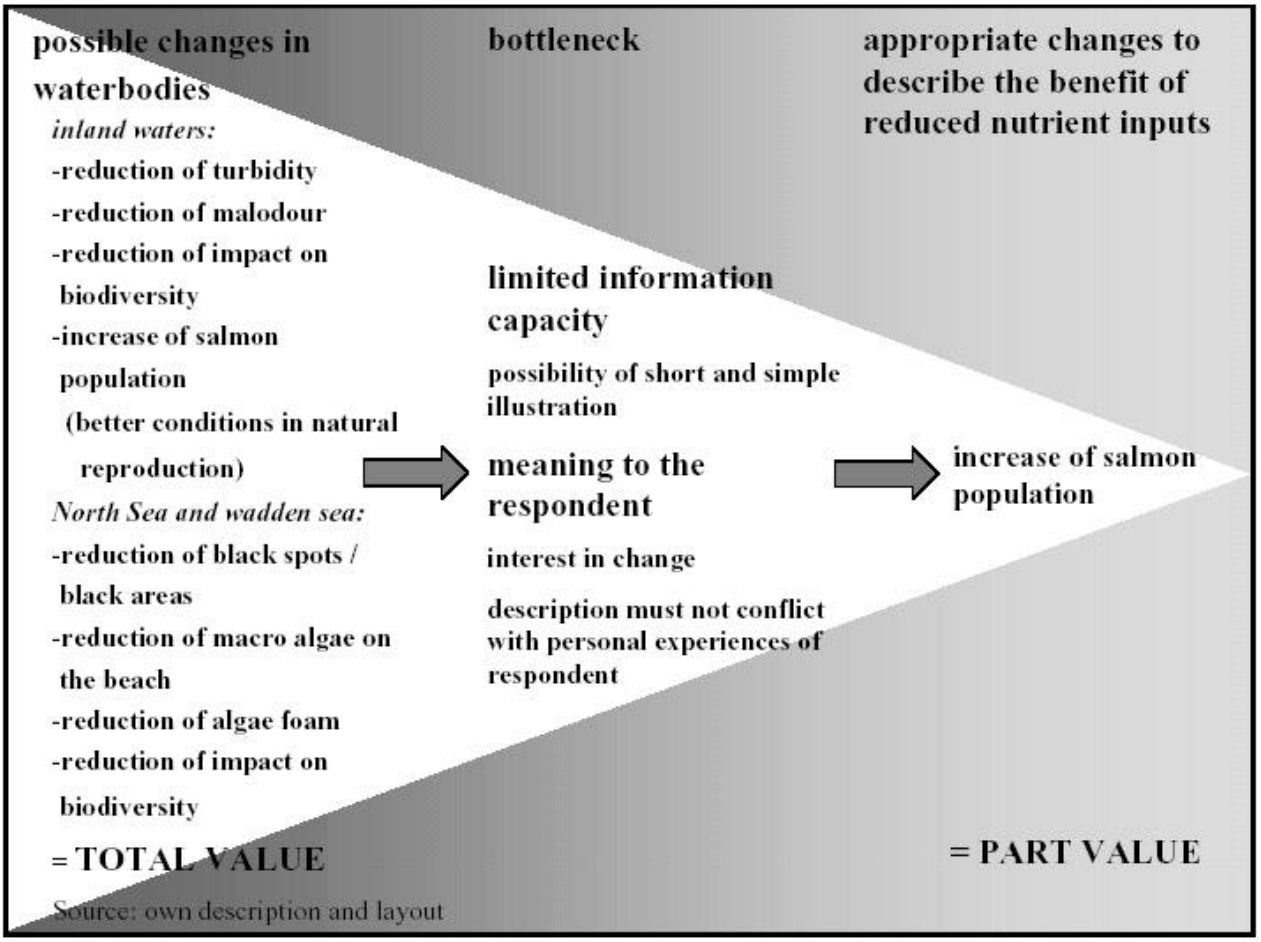


Figure 2: Choice of an environmental change scenario

As mentioned above, the accomplishment of a benefit function transfer bases on the availability of regional data. Against this background it is intended to survey socio-economic variables in spite of the fact that this kind of data did not contribute significantly to explain the amount of WTP in previous studies (see Enneking, 1998: 182). Nevertheless, socio-economic data is the only official data available on a regional level.

Concluding, the choice of salmon population as an indicator to describe impacts of reduced diffuse pollution implies on the one hand the drawback that a variety of other effects are suppressed and are not taken into account by respondents. On the other hand incorporating all possible effects to formulate an environmental change scenario does not guarantee that the respondent actually considers all aspects of the scenario in her/his WTP. This would give a wide scope of interpretation to the scientist and may lead to false conclusions.

Furthermore, expressed WTP bids do not relate to accurately defined but to qualitatively described changes in salmon population. Using WTP in the cost-benefit analysis requires assumptions concerning changes in salmon population, aware of the fact, that these assumptions must not correspond to the beliefs of the respondents. However, this approach is regarded more purposive to valuate benefits of reduced nutrient inputs than a confusing description of all possible effect.

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