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REPORT ON EVALUATION AND ASSESSMENT OF MANAGEMENT STRATEGIES AND TOOLS IN THE CONTEXT OF THE ELBE BASIN

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1 Introduction: the Elbe basin and major water-related problems

The Elbe River basin covers large parts of two countries - the Czech Republic and Germany. About 2/3 of the drainage basin area (148,268 km²) is located in Germany (96,932 km²), and 1/3 - in the Czech Republic (50,176 km²), and a negligible part of the basin is located in Austria and Poland. The basin covers different geographical regions from middle mountain ranges in the west and south to large flatlands and lowlands in the central, northern and eastern part of the basin. About 25 million inhabitants live in the basin, therein 76% in Germany.

The river basin is used for various purposes. Agriculture areas occupy 56% of the drainage basin, and 25% are covered by original forest. The industrial sector withdraws the largest amount of river water (about 70%), followed by the agricultural sector and the water withdrawals for domestic use (both about 15%). Water management in the whole Elbe basin is well developed and has a good potential to introduce IWMR. However, cross-sectoral and transboundary cooperation should be substantially improved.

The Elbe River is experiencing all three major water-related problems: having too much of water from time to time (floods), too little of water often in summer season (droughts), and having water of inadequate quality. In the last three years, extreme hydrological situations were observed on the Elbe - a destructive flood in August 2002, and a severe drought and water deficit in 2003. The disastrous flood in August 2002 has strongly shifted general public attention to the flooding problem. Besides, the Elbe is a major contributor of nitrogen and phosphorus loads to the Northern Sea.

The objective of this report is to present evaluation of the management strategies and testing of the tools for water management in the Elbe basin.

Evaluation and assessment of the management strategies was done using the results of the Questionnaire survey: Questionnaire on the State-of-the-art of River Basin Management in dealing with climate-related extreme events (Huntjens, 2008) for the Ohre river basin (subbasin of the Elbe), preliminary results of the Questionnaire on climate change adaptation in the Elbe basin, ICPE Report “Action plan for flood protection in the Elbe”, and the reports on strategy of protection against floods in Germany and in Czech Republic.

The following tools were tested in the Elbe basins: the ecohydrological model SWIM (Krysanova et al., 1998 & 2000), and the decision support tool Waterwise (van Walsum, 2007; van Walsum et al., 2008) for spatial land use planning.

2 Evaluation of the management strategies

2.1 Evaluation of the state-of-the-art management

The evaluation was done using the Questionnaire on “The state-of-the-art of river basin management in dealing with climate-related extreme events” (Huntjens, 2008), which served to provide an overview of the current river basin management in the basin. The research objective was an inventory of factors, which are important for effective water management

in view of increased frequency and intensity of climate-related extreme events. The Questionnaire was distributed in other NeWater case Study basins as well. Here only responses obtained in a subbasin of the Elbe were evaluated.

The Questionnaire was subdivided into ten categories:

A) Agency
B) Awareness Raising and Education
C) Cooperation
D) Policy development and implementation
E) Information management and sharing
F) Agriculture
G) Finances and cost recovery
H) Risk management
I) Infrastructure
J) Effectiveness of (international) regulation.

Each question included two possible answers describing the positive and negative status of the management. The respondent had chance to mark, which of these two answers is prevailing, or if the status represents medium situation between the two opposite conditions. The next step was to indicate the importance (or weight) of each indicator.

In the last part of the questionnaire inquiry the respondents have been asked to evaluate the indicators for measuring the performance or effectiveness of river basin management.

The Questionnaire survey was conducted in the Ohre River catchment (5870 km^2), one of the large subbasins of the Elbe. The Ohre River is located in the North-West Bohemia near German border and partly stretches into Germany (**Fig. 1**). Eleven respondents: experts from different water management practices and policy makers have been invited to participate in the inquiry. One questionnaire had to be excluded from the evaluation because of errors in the form.

In many cases, the answers of ten respondents differ significantly. Doing the evaluation, we have chosen the prevailing answers with $\geq$ 70%, and in some cases with $\geq$ 60%. The diversity of answers could be partly explained by different opinions amongst the respondents, and maybe partly by the complexity of the Questionnaire as a whole, as some respondents maybe felt incompetent to answer all the questions.

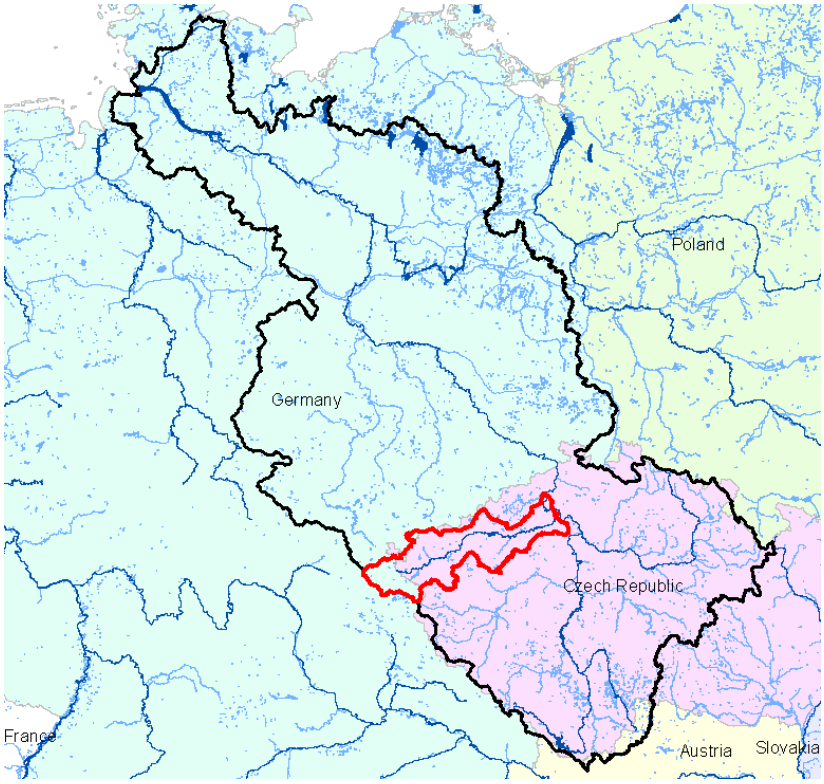

Fig. 1: The location of the Ohre River Basin (in red) as a sub-basin of the Elbe River Basin

Evaluation of category A: Agency

The first category concentrated on basin agency. The aim of this part was to assess the relationships between the leading organisations dealing with climate-related extreme events. The respondent had to indicate

- type of leadership and the organisation which is authorised to control the basin management under extreme events,
- the level of cohesion, and
- the level of authority.

According to the majority of responders, leadership has authority to act externally, takes advantage of exogenous factors, mobilizes allies, and effectively deals with barriers. The responders were less confident about the proactiveness of the leadership, and about ability of leadership to formulate and articulate internally consistent policy preferences (answers mostly between “medium” and “yes”).

The mobilisation of the allies and the proactiveness of the basin leadership have been fixed as the most important indicators. All six indicators were marked as important or very important by a majority of experts.

Evaluation of category B: Awareness raising and education

The second category was focused on the public awareness raising and education. The main evaluated topics were

- the public awareness programs on water problems,
- water education in schools, and
- water education for water practitioners and professionals.

In general, the level of awareness raising, existence of IWRM programs and programs for public awareness raising and education can be characterised as medium. Most of responders have chosen an option “medium in between”. The IWRM is not fully implemented in school education yet. However, all three indicators were marked as important or very important by all experts.

Evaluation of category C: Governance and cooperation

The governance and cooperation have been evaluated as the third category of the questionnaire. Five basic topics have been discussed in this part:

- type of the governance,
- level of stakeholder participation,
- level of cross-sectoral cooperation,
- level of cooperation between administration levels, and
- cooperation across the administrative boundaries.

Altogether, 14 points had to be answered. The governance could not be uniformly classified. The most frequent respond was that the fact could not be easily characterised by the given description and the situation correspond to the medium state between. A half of respondents indicated top-down governance in the basin as dominant, while another half answered “in between”. The type of governance was evaluated by a majority as important.

Most of responders indicated on existing legal provisions concerning access to information, participation in decision making and access to courts. Regarding stakeholder participation, most of answers were “in between”, which indicates that some stakeholder participation is taking place, but it is not yet sufficient. However, the majority found stakeholder participation important.

The experts evaluated the level of existing cross-sectoral cooperation as being between “medium” and “good”, and found it fairly important or very important. The cooperation between administrative levels was evaluated similarly: between “medium” and “good”, and important. Dealing with conflicts was found at the medium level for both cross-sectoral and administrative levels.

The majority of responders acknowledged that downstream governments are involved in decision-making by upstream governments, and that international transboundary cooperation structures exist. However, they were less certain about dealing with conflicts. This probably

indicates that sometimes conflicts are resolved constructively, and sometimes they remain unsolved. Almost all experts found the transboundary and downstream-upstream cooperation very important. The international transboundary cooperation was marked as the most important indicator.

Evaluation of category D: Policy development and implementation

The respondents had to assess

- the time horizon for the planning,
- type of the measures,
- level of the experimentation,
- consideration of possible measures,
- actual implementation of policies, and
- monitoring and evaluation.

The results show the same or similar situation for policy development and for implementation. No strict characterisation of the status could be done.

No clear answer was obtained on whether the solutions for short term problems cause or do not cause more problems in the future. The same uncertainty appeared on the point whether only short-term measures are undertaken, or also strategical solutions for future are taking place in water management now. Most answers were “in between”. Probably, the experts have different views about that, or maybe these are too difficult questions, and the responders did not dare to judge.

The experts were highly uncertain about the question whether the measures undertaken now or proposed for the near future are limiting the range of possible measures in future, and they could not answer definitely, whether small-scale policy experiments take place or not in the basin. Most answers were “in between”.

It was evident from the answers that several alternatives and scenarios are discussed during the planning in the basin. The next question about either “only large scale structural measures”, or “small and large-scale and structural and non-structural measures” are discussed was answered as “in between” by a majority. This probably indicates that either the experiences of experts in this respect differ, or the formulation of this question was not quite clear.

The questions about the implementation of policies were answered as “in between” by most of the experts. This probably means that sometimes policy and plans are implemented, and sometimes not. However, the majority indicated on existing steering committees for project preparation and implementation, and a half of experts acknowledged existing monitoring and evaluation plan during project preparation.

All ten indicators in this part were found important or very important by a majority of responders. The highest level of importance was assigned to the discussion of several

alternatives and scenarios, and the lowest (70%) was given to the small-scale policy experiments.

Evaluation of category E: Information management and sharing

The Information management and sharing have been assessed by the fifth category. In this category the following indicators were evaluated:

- joint information production,
- interdisciplinarity,
- elicitation of mental models,
- explicit consideration of uncertainty,
- broad communication,
- utilization of information, and
- decision support system.

In general, the respondents evaluated information management in the basin quite positively. Most of the experts acknowledged that different government bodies are involved in setting the Terms of References (project preparation document) and supervising the search for information, but they were not so sure about the involvement of non-governmental stakeholders in this process (only a half responded positively).

The question about interdisciplinarity (involvement of ecology and social science in the research) was responded rather positively.

The question whether the researchers allow or not their research to be challenged by stakeholders was answered as “in between” by a majority. Most of the responders acknowledged that usually the research results are presented in a facilitative way in order to stimulate reflection by stakeholders.

90% of the responders answered that uncertainties are communicated in reports and orally, and are not glossed over. According to a half of experts, researchers are willing to talk with stakeholders about uncertainties. Another half has chosen the answer “in between”.

The majority agrees that governments exchange information and data with other governments, but they were less sure (50% of positive responses, and 50% “in between”) about the dissemination of governmental information to the public.

The responders agreed that new information is mostly used in public debated and is not distorted, however they were less sure whether new information influences policy or not (40% of positive responses, and 60% “in between”). 70% of experts think that river basin information systems are up to standards.

All indicators in this category were found important by a majority of experts. The lowest importance (60%) was assigned to the involvement of non-governmental stakeholders in the process of information production.

Evaluation of category F: Agriculture in the basin

This part of the Questionnaire was focused on:

- research and development of high resilient crop seeds,
- flexibility in crop rotations, and
- crop choice.

For all three questions most of the experts have chosen the answer “in between”, or there was no response. This is probably due to the fact that they experts involved did not fill competent enough to answer these questions related to agriculture management.

Nevertheless, most of them acknowledged the importance of all three indicators (60 – 80%).

Evaluation of category G: Finances and cost recovery

The category “Finances and cost recovery” has dealt with

- availability of resources,
- cost recovery,
- allocation of resources, and
- private sector participation.

It looks like there are not sufficient resources in the basin (50% of negative responses), nevertheless the costs are mostly recovered from the users by public and private financial instruments. The responders had different views about the ability of authorities to take loans and depreciate their assets, and they found the level of diversification of financial resources and the participation of private sector in river basin management to be intermediate.

The most important indicators are availability of the sufficient financial resources and economic instruments for cost recovery. The ability of authorities to take loans and depreciate their assets was found to be of minor importance, and a half of experts could not respond on this question.

Evaluation of category H: Risk management

The category risk management was the most cohesively assessed by the respondents. The topics discussed were:

- risk perception,
- decision making on acceptable risks, and
- insurance against risk.

The respondents had different views on the question, whether only formal expert judgement of risks, or both formal expert judgement and risk perception by the stakeholders are taken into account in the basin. They were also not sure, whether non-governmental stakeholders

are involved in decisions on acceptability of risks or not (diversity of answers). These both points got also less rating on the importance compared with others in this category.

Existence and importance of all kinds of insurances was confirmed by a majority of experts: both obligatory and voluntary insurances against houses and property damage and against crop damage.

Evaluation of category I: Infrastructure

The infrastructure was evaluated according to the following indicators

- scale of infrastructure,
- sources of the design,
- sources of power delivery, and
- ownership.

The question about scale of infrastructure was answered by a majority as “in between”, which means that both massive centralized and small-scale decentralized infrastructure exist in the basin. The experts confirmed that there are diverse sources of power delivery. However, they were rather uncertain about single or diverse sources of design for infrastructure, and about public or public and private ownership of infrastructure (diversity of answers).

The majority of responders found the indicators “scale of infrastructure” and “sources of power delivery” important, whereas sources of design and ownership were evaluated differently by the experts.

Evaluation of category J: Effectiveness of international regulation

The effectiveness of the international regulation was assessed through

- level of compliance, and
- adoption of international regulation.

Two indicators of the level of compliance: whether coercive sanctions are used as legitimate means of generating compliance in hierarchical context or in horizontal setting were evaluated quite differently by the experts: “yes” and “no”, and “in between”. The question about soft paths to compliance in place (e.g. capacity building, legitimacy building, etc.) was responded more positively: 50% of positive answers, and 50% “in between”.

The responders acknowledged the country adoption of specific water-related reforms, policies, standards and programs necessary to address the transboundary issues. Only a half of experts were sure about the ratification of the regional or global conventions and protocols by the country. 60% of responders confirmed a high-level commitment to follow joint actions as signed at the ministerial level, and 40% responded “medium”. The experts were quite positive about the country commitment to report progress in achieving the goals to the regional or joint institution (50% “yes”, 50% “medium”). They had different views on

the incorporation of country assistance strategies in the World Bank or a regional development bank (diversity of answers).

The country adoption of the legal reforms, the county ratification of the regional or global conventions and protocols, and a high-level political commitment to follow up joint actions were marked as the most important indicators in this category.

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The overall picture of responses on all 72 questions in 10 categories is the following: the majority of responders have chosen the first (definite) option 15 times, third (definite) option 9 times, and the option “medium, or in between” 22 times. No dominant answer could be chosen in 26 cases out of 72 (36%). The choice of an option “in between” in so many cases probably indicates either the moderate level of existing management of climate-related extremes, where many procedures still need improvements, or uncertainty of the experts in finding the definite answer. Quite a high percentage of indefinite answers (no dominant reply) may result from a complexity of the Questionnaire as a whole, and not clear formulation of questions in some cases.

The importance of indicators was confirmed by a majority of experts. They were evaluated as important or very important by 8 to 10 experts in 53 cases out of 72, and by 6 to 7 experts in 15 cases out of 72. This shows that most of the responders acknowledge the importance of included indicators, and that it was much easier to evaluate the importance than the real implementation.

2.2 Evaluation of indicators for measuring the performance of management

In the last part of the questionnaire inquiry the respondents have been asked to evaluate the indicators for measuring the performance or effectiveness of river basin management. The indicators were subdivided into four different management categories:

- extreme events,
- water resources,
- agriculture,
- managing for resilience of ecosystem.

The respondents assigned the weight to each indicator, which should be representative for the outcomes of managing specific category. They had an opportunity to add missing indicators.

In the category “Extreme events” the following three indicators have been chosen as most important: number of flood victims, number of drought victims, water storage capacity to protect against floods (was added!) and to secure minimum flows in dry periods, and damage caused by flood. The importance of water storage capacity to protect against floods was added, as it was missing in the original Questionnaire.

In the category “Water resources” the following important indicators were chosen: groundwater recharge per capita, access to improved water resources (in general) and access to improved water resources in urban areas.

In the category “Agriculture” all indicators were evaluated as moderately important, no prioritization can be found. Only the indicator “water consumption per unit of production” got a bit higher score. The percentage of arable land was added as a new indicator for this category.

According to the responses, the most important indicators for managing the ecosystems are: reduced pollution of groundwater and implementation of non-point source pollution program (best management practices). The increase of the retention capacity of the landscape has been added to the indicators.

2.3 Strategies in water management to cope with climatic hazards

In the future climate, higher average temperatures and lower precipitation in summer are projected for the basin. This indicates that the water scarcity problem in this densely populated basin will grow, with adverse consequences to several sectors, such as agriculture, forestry, water supply, navigation and recreation. The projected decrease of precipitation in summer could also aggravate the drought risk. On the other hand, the intensity of rainfall and, as a result of that, the frequency of floods are expected to increase under climate change in the Elbe basin (Becker and Grunewald 2003). The need to develop proper flood management measures and strategy is recognized.

Two main elements of flood risk management in the basin are reduction of flood risk and coping with floods. Preventative measures against flooding (Flood risk, 2004) combine engineering facilities, river basin planning along with financial and social measures. They include:

1. Technical flood protection: facilities for water retention such as dams, storage reservoirs, and polders;
2. River basin planning: increasing natural water retention in catchment areas;
3. Spatial planning: keeping constructional development as far as possible out of floodplains;
4. Constructional measures: ensuring appropriate construction methods in areas prone to flooding;
5. Risk spreading methods: financial provisions backed by insurance;
6. Behavioral or social measures: explaining, preparing for, and practicing ways in which to cope with dangerous flood-related situations; and
7. Informational measures: flood alarm and warning systems.

The coping with flood disaster above all means: help for flood victims, averting disastrous impacts of flooding, and help in reconstruction.

Measures used in water management now, which are especially necessary in periods of droughts, are water saving technologies, water price mechanisms, and optimization of water

resources use. In future, some other measures like land cover change, introduction of new crop varieties could be needed under drier climate, and such measures as water saving technologies and optimization of water resources use will have to be enforced.

The Action Plan for the flood protection in the Elbe river basin (ICPE)

The Action Plan for the flood protection in the Elbe river basin was prepared within the International Commission for Protection of the Elbe (ICPE) and approved on October 21 – 22, 2003 at the 16th ICPE Meeting in Erfurt. It was based on mapping of the existing level of flood protection in the Elbe river basin and on the evaluation of the September 2001 flood event data. This document is based on two fundamental principles for flood protection: 1) increasing the retention effect in the basin, and 2) delineation, declaration and utilization of flood prone areas in the basin.

The following tasks were defined in the Action plan:

- moving the protective levees farther away from the watercourses (2 700 ha), and creating more retention space in 16 localities, in which controlled polders might be built (with a capacity 178 mill. m^3);
- elimination of technical flaws in the protective levees located along the Elbe River watercourse and on the levees holding the returning water on the Elbe tributaries in Germany (548 km of levees (45% of all existing levees) should be reconstructed by 2015);
- assessment of the impacts of large dam reservoirs (located on the Vltava, the Ohre, and the Saale rivers) on the Elbe River flood development;
- studies for the cities in the Czech Republic that are threatened most on implementation of technical flood protection measures based on the outflow conditions;
- to develop requirements for the technical facilities handling substances that jeopardise the water quality in flood prone areas;
- improving the flood information system by establishing a joint international flood forecasting system, and upgrading the technical equipment at the flood warning and forecasting profiles and in the meteorological monitoring networks.

The common Czech-German flood forecasting system can further be improved by using the latest upgraded models. The objectives are to lengthen the forecast periods and to improve the accuracy of forecasts.

This plan helped to draw conclusions of the August 2002 flood so that they could be transferred into specific schemes. The evaluation of the period between 2003 and 2005 contained

- the analysis of flood risks,
- the flood warning and forecasting system, and
- the measures to improve the retention effect of the technical flood protection measures

Significant results were achieved since the time when the Action Plan was created. The involvement of NGOs and relevant research projects at the European and national levels

definitively contributed to the transparency of plans and to the integration of the current state of knowledge into the new developments.

Flood protection in the Czech Republic

There is no specific Program or Plan of activities and measures directly related to climate change adaptation in the Czech Republic, but there are following documents considering this issue:

- Plan of Main River Basins of CR. (Act No. 254/2001 Coll. § 24, was ratified by government resolution on 23 Mai 2007, N. 562);
- National sustainable strategy of the Czech Republic
- amendment to the Water Act, which is now under approval procedure in the Senate.
- Government Decree N. 229/2007.

The Czech Government has assigned a task to prepare a Strategy of protection against floods as a basis for preparation of necessary measures. The principles of the Strategy of flood protection in the Czech Republic were derived from the analyses of the floods in the Czech Republic and experience from other countries:

- Preventive measures for protection against floods represent the most effective type of the protection;
- Owners and administrators of properties should be involved in the implementation of preventive measures for reduction of flood damages;
- Effective preventive measures have to be taken in the areas of river basins taking into account integration of effects of individual measures along watercourses;
- It is necessary to select a suitable combination of land improvements, which support natural capacity to retain water, and technical measures affecting flood discharges;
- It is necessary to use reliable information on geomorphological conditions, vegetation cover and soil types, and to apply advanced information technologies allowing simulation of floods and assessment of the effectiveness of the selected measures;
- It is necessary to ensure an improvement of information systems providing information during floods and to improve preparation of flood protection plans;
- It is necessary to resolve problems associated with flood protection within the framework of international cooperation, mainly through implementation of the adopted international agreements on cooperation in basins of transboundary rivers;
- With respect to financial requirements, the implementation of effective flood protection measures is a long-term objective and the state policy will be aimed at supporting preventive measures preferably to compensating flood damages;

The main pillars of the Strategy for protection against floods are:

- Flood forecasting and warning service,
- Flood control measures,
- Improvements in land use,
- Technical measures,

- Reduction of risks to population and potential damages,
- Delimitation of flood plain areas,
- Regulation of use of flood plain areas,
- Protection of property.

Preventive measures play an important role in the Strategy of protection against floods. These measures contain also assessment of research results:

- Assessment of current conditions including delineation of flood-prone areas, areas exposed to risk in case of foods, and estimation of potential flood damages;
- Development of preliminary alternatives of flood protection measures, including evaluation of associated costs, technical feasibility assessment and environmental impact assessment;
- Implementation of risk analysis and determination of a degree of the flood protection, discussion and consideration of the preliminary alternatives and selection of a final alternative.

We can summarize that the technical measures are on a high level in the area of the Czech Republic. However, the soft or non-technical measures are becoming better accepted among policy makers on different levels. For example, the implementation of emergency and disaster recovery committees, household mitigation and preparedness actions and climate-related hazards insurance, information and education on flood protection issues, improvement of transboundary cooperation (monitoring, early warning) have already started in the Czech part of the basin. These conclusions follow from the Questionnaire responses and interviews, which were carried out in the Czech part of Elbe basin for the Synthesis Product on "Cross-Comparison of Climate Change Adaptation Strategies across Regions".

3 Testing the tools

In the framework of the Elbe case study three major tools:

- questionnaire surveys,
- the ecohydrological model SWIM (Krysanova et al., 1998, & 2000), and
- the decision support tool Waterwise (van Walsum, 2007; van Walsum et al., 2008) for spatial land use planning

were tested. Two Questionnaire surveys conducted in 2005 and 2006 were previously described in Deliverable 3.3.4. The results of the Questionnaire on "The state-of-the-art of river basin management in dealing with climate-related extreme events" (Huntjens, 2008), which served to provide an overview of the current river basin management in the basin, were presented in Section 2 of this report. Therefore, here the testing of tools SWIM and waterwise will be shortly presented.

3.1 Testing the ecohydrological model SWIM

In the Elbe case study the ecohydrological river basin model SWIM (soil and water Integrated Model) was widely used for the assessment of land use / climate change impacts on water availability and quality. SWIM simulates hydrological processes, vegetation and nutrient cycles at the river basin scale (Krysanova et al., 1998, 2000) by disaggregating the

basins to subbasins and hydrotopes. SWIM was applied in three subcatchments of the Elbe: the Rhin in the German part, and the Jizera and Malse-Rimov in the Czech part. The modeling was done in close collaboration with stakeholders interested in the assessment.

Application of SWIM in the Rhin catchment

PIK provided requested modelling results obtained with SWIM to the stakeholders from the Federal Environmental Agency of Brandenburg (LUA). The LUA objective is to develop an implementation plan of the Water Framework Directive (WFD) for the Rhin catchment, which is a representative catchment for the State of Brandenburg. The modelling results are used to support the implementation of WFD.

Water quality modelling in the meso-scale Rhin catchment in the German federal state Brandenburg was done 1) to answer some specific questions concerning identification of point and diffuse sources of nutrient pollution in the catchment, 2) to assess the influences of possible climate and land use changes on water quantity and quality and 3) to evaluate potential measures to be done in order to achieve a “good ecological status” of the river and its lakes as required by the Water Framework Directive (WFD). The Rhin catchment is a typical highly regulated lowland river basin in Northern Germany. The regulations complicate water quantity and quality modelling in the catchment.

After calibrating the hydrological processes at different gauges within the basin with satisfactory results, water quality (nitrogen and phosphorus) modelling was done taking into account the emissions of different point sources (sewage treatment plants etc.) and identifying the amount of diffuse pollution caused mainly by agriculture.

For suggesting some feasible measures to improve water quality and to reduce diffuse pollution considering possible climate and land use changes, six different reasonable scenarios were applied in consultation with LUA. The study revealed that the amount of water discharge has significant influence on the concentration of nutrients in the river network, and that nitrogen pollution, caused mainly by diffuse sources, could be notably reduced by application of agricultural measures (reduced fertilization rates and changed crop composition), whereas the pollution by phosphorus could be diminished most effective by reduction of point source emissions.

As none of the six tested scenarios resulted in considerable decrease of nutrient loads and concentration for both nitrogen and phosphorus, a combination of measures was tested, which would allow notable improvement of water quality. According to this scenario, nitrogen as well as phosphorus loads and concentrations would be reduced by about 15%. This would allow pushing the system closer to the “good ecological status” as required by the WFD.

The ecohydrological river basin model SWIM has proven to be a robust and useful tool for water quality assessment, and for studying impacts of climate and land use change impacts.

Application of SWIM in the Jizera catchment

The Jizera catchment (NE Bohemia, about 2000 km^2) was chosen for the focused research in the NeWater project in cooperation with the key stakeholders: the Czech Ministry of Agriculture and the Czech Ministry of Environment. The main reasons were: very important for the Prague water supply water treatment plant Karany located in the catchment, rapidly developing tourism and building industry in the mountains, extensive agriculture in lowland, and possible low water availability and water quality degradation in future due to regional impacts of climate change.

Major research needs for the Jizera catchment were defined with stakeholders at the workshop held in the catchment in October 2005. They are: water quality, drought impact on water availability, and land use change impact on water quantity and quality. Nutrient pollution was recognized as the most important problem. Several types of nitrogen pollution sources exist in the Jizera basin: point sources (sewage water treatment plants), small settlement without sufficient sewage water treatment, and non-point sources (caused mainly by pollutant leaching from agriculture areas). All types are important, and there is no one prevaling type of nutrient pollution in the catchment. As follows from the results obtained so far, small settlements with insufficient treatment of sewage waters represent an important source of nutrient pollution in the catchment. In future, water quality in streams and in the main river course may worsen due to impacts of climate and land use change. All these questions: shares of different sources of pollution, impact of land management and land use, impact of climate change need further research, where ecohydrological modeling could be helpful. Until now, the model SWIM was successflully calibrated and validated for hydrological processes in the Jizera, and water quality modeling has started.

The issue of better water quality in the case of the Jizera catchment (and in the whole area of the Czech Republic) is closely associated with awareness of local authorities and inhabitants themselves. Scientific results are respected, so the intention is to continue the started ecohydrological modeling and assessment using results of monitoring, and to provide results of research to the local stakeholders.

Application of SWIM in the Malse catchment

The model SWIM has been applied and implemented in the Malse basin, it was successfully calibrated and validated. The additional climate data from the Austrian part of the basin were incorporated to the model. The accuracy of the simulations was evaluated in comparison with the observed data.

The requested by stakeholders creation of the climate change scenarios has been started. The data for the climate change simulations were obtained in cooperation with MPI Hamburg and German Federal Environment Agency. The climate scenarios based on the regional climate model REMO were extracted from the database and the local scenarios for the Malse basin were downscaled. The new input climate data for the SWIM model are being generated now. The next step will be simulation of hydrological dynamics under climate change for the Malse basin based on the obtained REMO scenarios.

There are several publications presenting the modelling results obtained with SWIM for the Elbe basin: Hesse et al., 2007; Hesse et al., 2008; Hattermann et al., 2008 and Koskova et al., 2007.

3.2 Testing the tool Waterwise in the Elbe basin

Waterwise is a decision support tool for spatial land use planning and water use strategies. This tool was chosen as a part of the Train the Trainers activity organized by Work Block 4 of NeWater. Waterwise is an interface for economic optimization of land use in relation to water quality and quantity downstreams. This tool requires outputs of catchment-scale model(s) for regional bio-physical, hydrological, water quality and economic data. Tailoring Waterwise to regional condition needs preparation time to obtain the required accuracy and timely support of stakeholders.

Waterwise was chosen for testing in the Elbe case study. The introductory training was organized by Work block 4 of NeWater. For that, a demo version of Waterwise made with data from a Dutch subbasin, which has similar features as the Elbe regarding land use, climate and nutrient cycling, was used. The training aimed in the introduction of the tool for potential trainers, and took place during a Workshop in May 2007 in Potsdam. It became clear at the Workshop that prior to Waterwise application, an ecohydrological model (e.g. SWIM) has to be applied to get water and nutrient fluxes in the catchment subdivided into subbasins. Besides, economic data on nutrient abatement strategies had to be collected.

After the Workshop the following decision was made:

- to apply the model preliminarily for a subcatchment of the Elbe (e.g. in Thuringia) using as much as possible regional data,
- to demonstrate preliminary results for the policy makers in the region, and
- in case of agreement with the policy makers to proceed with a more complete application in collaboration with stakeholders in the same or other catchment, which is of interest for the regional policy makers.

In the period November 2007 – February 2008 a coupled SWIM-Waterwise application was developed for the Wipper catchment located in Thuringia in the western part of the Elbe basin. The objective of the application was optimization of land use aimed in improvement of water quality. In order to assess water and nutrient fluxes in the catchment, firstly the model SWIM was applied. Finally, Waterwise was linked up with the outputs of SWIM and parametrized with relevant land use and economic data of the region.

A prototype of the land use optimization was demonstrated at the Workshop “Optimization of land use in river basins aimed in improvement of water quality” at the Thuringian Ministry of Agriculture, Nature Protection and Environment (TMLNU) in Erfurt on March 27 and 28, 2008. The Workshop objectives were to present the modeling tools SWIM and Waterwise, to learn about the specific water quality problems in Thuringia, and possible ways to solve these problems and to meet the requirements of the WFD in the region. During the Workshop, the tools SWIM and Waterwise were demonstrated, and a prototype application for the Wipper was presented. The following questions related to the modelling tools were discussed:

- What results can be obtained from the modelling with SWIM and Waterwise?
- On which basis is the modelling performed? Which input data are needed?
- What is the experience of the models application in other areas?
- How the models can be used for water and land use management?

The following important questions related to water quality problems in the region were discussed during the Workshop:

- Does the problem of nutrient pollution really exist in Thuringia?
- Which pollutant is more important: Nitrogen or Phosphorus, and in which subbasins?
- Problems with point and diffuse sources are different, which are more important for Thuringia?
- What are the possibilities to solve water quality problems in Thuringia?
- Are there other important problems in the region (e.g. restructuring of the rivers), where modeling support would be needed?

During the second day of the Workshop, a field trip was organised to the Wipper and Helme area in Thuringia. During the excursion water quality problems and prospects of Waterwise-SWIM application in the area were discussed.

Summary of the workshop discussion

The discussion about the regional water quality problems and tools can be summarized as follows.

Waterwise is a decision support tool for spatial land and water use strategies application. It optimizes income for land use shifts required under existing water regime to reach the desired water quality standards (for example, WFD). When properly prepared, the tool Waterwise can incorporate (old and new) knowledge on land and water relationships in a way that can be directly operational during the stakeholder sessions. The more management options are incorporated, the better advantage can be taken of the Waterwise to provide clear views of a complex reality.

The Waterwise was linked with the ecohydrological model SWIM at the level input-output. Incorporation of land use scenarios options (like demonstrated for the Wipper case study) needs some preparation time. Results of certain research questions now critical for Thuringia could be incorporated as scenarios and options in the modelling framework (like surface water – groundwater relations, lake reactivation, P pollution, and effects of climate change). Once the options and scenarios are included, the tools can be processed to test different management options. This is possible in a stakeholder session, and consequences of management suggestions can be directly available. The impression of the Workshop participants was that the coupled application of Waterwise and SWIM for WFD implementation could be useful and realistic under certain conditions.

A meaningful application of Waterwise and SWIM in Thuringia requires fulfillment of the following basic conditions:

- stakeholders interactively work with modelers towards a solution of the problems,
- timing of tool application in the process is appropriate, and
- incorporated changes of land use are considered as realistic options.

The usefulness of tools Waterwise and SWIM and relevance for the real problems in the region were confirmed, but the timing of the WFD-related stakeholder process was found not favourable. The main reason was that the plans and measures for WFD implementation in the region were just compiled, and there was no sense to start all the process again. Keeping in mind that the NeWater project is finishing in 2008, there was no possibility to suggest a longer strategy continuing after 2008.

Anyway, the experience of tools testing in the Wipper catchment could be useful for further applications of Waterwise in other catchments.

4. Policy summary

Water management strategies
The evaluation of Questionnaire results for the Ohre basin allows to summarize state-of-the-art river basin management for the Czech part of the Elbe, and to some extent it is also valid for the whole Elbe basin. **Leadership** has authority to act externally, takes advantage of exogenous factors, and mobilizes allies. The level of **awareness** raising, existence of IWRM programs and programs for public awareness raising and education can be characterised as medium. The **governance** could not be uniformly classified: a half of respondents indicated top-down governance in the basin as dominant, while another half answered "in between". Most of experts evaluated the level of existing cross-sectoral and transboundary **cooperation** as well as cooperation between administrative levels as "medium". Regarding stakeholder participation, most of answers were "in between", which indicates that some stakeholder participation is taking place, but it is not yet sufficient. It was evident from the answers that several alternatives and scenarios are discussed during the **policy development** and planning in the basin. In general, the respondents evaluated **information management** in the basin quite positively, though the involvement of non-governmental stakeholders is minor or not existing, and the dissemination of governmental information to the public is insufficient. It looks like there are not sufficient **financial resources** in the basin, nevertheless the costs are mostly recovered from the users by public and private financial instruments. Existence and importance of all kinds of **insurances** was confirmed by a majority of experts: obligatory and voluntary insurances against houses and property damage and against crop damage. The question about scale of **infrastructure** was answered by a majority as "in between", which means that both massive centralized and small-scale decentralized infrastructure exist in the basin. The responders acknowledged the country adoption of **international water-related regulations**, policies, standards and programs necessary to address the transboundary issues.

The evaluation allowed to find out categories and issues in need of improvement, like cross-sectoral cooperation, dealing with transboundary conflicts, implementation of IWRM in education, and enhanced stakeholder participation.

The choice of an option "in between" of two opposite options in many cases probably indicates either the moderate level of existing management of climate-related extremes, where many procedures still need improvements, or a diversity of views of the experts, or a complexity of some questions and uncertainty of the experts in finding a definite answer.

The efficiency in dealing with conflicts and awareness raising should be enhanced, for example by better involvement of IWRM and AWRM into the management rules and education. The IWRM knowledge should be disseminating by special workshops for the water managers and by adaptation of the IWRM methods into the common rules and management software tools. The IWRM should be a basic part of the water management education. Several steps could be useful for enhancing the basin water management:

- wider access of public to the relevant information and data,
- development of a clear strategy for planning in view of global change and negotiations for a wider agreement between governmental authorities, non-governmental bodies and public,

- establishment of clear indicators of the positive and negative effects – not only for water quality and quantity (they do exist), but also for environmental, economics and social aspects,
- higher usage of the sophisticated decision support systems in water management,
- enhanced support for the downscaling of the EC rules and knowledge dissemination at the local municipality level.

Tools

In general, future water management decisions should be more adaptive, as we are living in a rapidly changing world. It can not be expected that the former conditions will stay unchanged. For this reason, scenarios as different options for a possible future should be taken into account. Model scenarios can be helpful in order to find reasonable measures for achieving a better ecological status taking into account possible changes of land and water use, management practices and climate conditions.

However, experiences of different European and national projects revealed as well that the available models and model systems are still far from being suitable for operational applications. This is especially the case for modelling of water quality, like simulation of nutrient transport and nutrient turnover processes, where the results of different models for nutrient concentrations in rivers differ often by more than 100% and are sometimes even contradictory. There are different reasons for such a problematic result as for example uncertainties in input data and model parameterisation, insufficient data support, deficits in model structure, spatial distribution and process description, and inexperienced model users. To overcome these problems not only more intensive research in improving the model systems is necessary but also a closer cooperation between model developers with model users and experts knowing the specific problems of the study areas. A close cooperation of the research institutes and the executive agencies can help to find suitable operational application measures.

Modelling experiments can help to understand the river system behaviour better. Especially for identifying the fractions of point and diffuse sources at the outlet of a river system and the areas of highest diffuse pollution the model can be very useful. Knowing these sources and hotspot areas, it is easier to identify useful measures for reducing actual nutrient loads in the river network and for achieving the “good ecological status”. A dynamic catchment model taking into account water and nutrient processes as a function of vegetation, land use and human impacts, driven by climate conditions, can provide a very functional tool for creating a river basin management plan taking into account possible changes, which the basin could be confronted with in future.

A healthy ecosystem requires a good water quality (WFD). In the prevailing regional setting measures can be taken in the water system to control and substantially reduce point-source pollution. In the case of diffuse pollution originating from the specific land use Waterwise can offer the community a way to decide on the most economic land use shift embedded in a guided stakeholder process to develop and to give feedback on planning and design.

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