NeWater

DELIVERABLE 4.2.3:
REPORT – FAST TRACK ENHANCED TOOLS

Produced by WP42

Report of the NeWater project -
New Approaches to Adaptive Water Management under Uncertainty

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Title	Specification for the enhancement of existing tools
Purpose	This deliverable describes the tools enhanced in a fast track development process between May 2006 and January 2007 (with exception of two tools which were finished in may 2007). The reports explains the choices behind the selected tools, summarises the enhancements and presents the enhanced tools which are included in annexes. The document also gives an overview of how the knowledge collected during the enhancement will be applied by the development of new tools (del 424) and how the fast track tools are being applied in the case studies.
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Executive Summary

Within the Newater project, the work package 42 focuses on tools and their enhancement to render water resource management more flexible and reflective. The enhancement is defined here as any improvement of the content, methodological background and transferability of a tool, or any other support measures which increase the users' ability to apply the tool. Since May 2006 the WP engaged in the fast-track enhancement of the selected tools for an early use in the Newater case studies. This deliverable (del 423) summarises the outcomes of the fast-track enhancements, describes the enhanced tools in detail and explains the choices behind the selected tools. The tools or the respective report are included in annexes. Besides the tools themselves, this deliverable contains progress report from a practical application of the tools in project's case studies (including a feedback from the intended users) and leaflets of each enhanced tool for a broader dissemination. The document also gives an overview of how the knowledge collected during the enhancement will be applied by the development of new tools (del 424).

The enhancements have been carried out in collaboration with case studies, especially with these which displayed limited capability to employ the corresponding tool and willing to make use of project resources to a cooperative specification, testing and/or application of the enhanced tools to real world management issues faced. The enhanced tools comprise a wide variety of tools useful at various stages of the IWRM. The tools include (the abbreviations in bold are used throughout the document): The Bayesian Networks for participatory model building (**BN**); GWP Handbook supplement (**GWP Supplement**); Enhanced Stakeholder-Issue Analysis (**ESHA**); GANetXL software environment for genetic algorithms (**GA**); Adaptive Monitoring Design Support System (**AMDSS**); Guidelines for successful application of DSS (**DSS Guide**); and **Waterwise -** an optimisation, bio-economic model.

These tools are useful at different stages of the (somehow idealised) policy cycle. The distribution of the enhanced tools' competences is well balanced: tools like BN, ESHA, AMDSS provide valuable insights into the management problem at hand and help to define its most salient features. Other tools such as BN, GA, WATERWISE are suitable at a later stage to assess effectiveness of policy options and to stimulate value judgements and building of consensus. Yet other set of tools (GWP Supplement, DSS Gudie) provide guidance throughout the whole policy process.

The WP42 partners focussed on various enhancements which include awareness rising and capacity building (GWP Supplement); better documentation (Waterwise, BN, GA), guidance in application of the tool (DSS Guide); novel approaches to assessment of the tool performance (BN); improving the transferability of the tool or its results (Waterwise); making the tools more flexible and applicable in context of adaptive management (ESHA, GA, AMDSS). The in-depth description of the enhancements is given in the section 2 and in the annexes dedicated to each enhanced tools.

In several cases the test/application and the further development/enhancement are continued elsewhere in the project. This is important because the time allocated to the enhancement exercise was not always sufficient to guarantee a successful implementation of the tools in the case studies.

The deliverable is structured as following: In the section 1 the background of the fast track exercise is explained and the corresponding WP42 activities are described. The section 2 briefly summarises the features of the enhanced tools, explains the result of the enhancement and review the lessons learned. The section 3 provides an outlook about what additional tools, new or existing one, will need to be developed or enhanced by the WP42 in order to develop a consistent 'toolkit', in which a range of different tools and approaches will be packaged or consolidated with associated guidance and decision support facilities that meet the stated needs of the case studies. This toolkit will be organised around the double loop policy diagram developed in WP17 and this document provides a brief reflection about how the double loop diagram can facilitate the selection of the tools to focus on until the end of the project (task 424).

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List of abbreviations

AMDSS - Adaptive Monitoring Design Support System

BN - Bayesian Networks for participatory model building

DSS Guide - Guidelines for successful application of DSS

ESHA - Enhanced Stakeholder-Issue Analysis

GA - genetic algorithms

GANetXL - software environment for genetic algorithms

GWP - Global Water Partnership

GWP Supplement - the supplement to enhance the Global Water Partnership's Handbook, "Catalyzing Change: A handbook for developing integrated water resources management

IWRM – Integrated Water Resource Management

Waterwise - an optimisation, bio-economic model

WB – work block

WFD – EU Water Framework Directive

WP - work package

1 Introduction

1.1 WP42 in the context of the Newater project

Within the Newater project, the work package 42 focuses on tools and their enhancement to render water resource management more flexible and reflective. In the first two project years (2005-2006) the WP (i) produced a state of the art report (deliverable 421), conveying the potential for IWRM and limitations of a variety of tools uncertainty assessment, integrated frameworks, valuation, decision support systems, participatory processes) and toolboxes (e.g. GWP and Harmoni-Ca toolboxes; (ii) identified a series of gaps of the tools above, both in their methodological background and ability to address the complex management problems; (iii) selected tools for a fast-track enhancement and early use in the Newater case studies; and (iv) specified the enhancements in terms of content and delivery. The points I and ii were addressed in the deliverable 421, while the points iii and iv are subject of deliverable 422.

This deliverable (del 423) summarises the outcomes of the fast-track enhancement, describes the enhanced tools more in detail and explains the choices behind the selected tools. The tools or the respective report are included in annexes. The document also gives an overview of how the knowledge collected during the enhancement will be applied by the development of new tools (del 424) and how the fast tracked tools are being applied in the case studies.

The expected date of delivery for this deliverable was month 24. At that time all tools except two (ESHA and GWP Supplement) had been uploaded in the Newater internal portal and an interim version of this deliverable was produced. The reasons for the remaining two tools not being ready at the end of the month 24 was the late involvement of the partners responsible for their enhancement. As explained in the Management Report 2006, HR Wallingford and Cemafreg withdrawn from the WP42 and were substituted by University of Cranfield and Technical University of Delft. To consent the new partners to complete the enhancement, the delivery of the final version of this deliverable was postponed by six months (to the month 30).

1.2 Tools and why they need to be enhanced: “hammer” and “nail”

To place the fast-track enhancement into a broader context within the Newater, one may paraphrase an old saying: “*Everything looks like a hammer, if all you have is a nail*”[1]. The nail in the saying is a metaphor for a management problem, an issue water policy makers have to solve, e.g. how to deal with excessive surface water without compromising the landscape capacity to store water? This problem, which is one of the issues tackled in the Tisza case study, had been solved for decades by building drainage networks and bringing water out of landscape as soon as possible. With the increased frequency of droughts and floods in the same area, these solutions are no longer appropriate. Persistent use of usual tools and management strategies in context of novel problems or circumstances in which old management problems are reformulated leads eventually to more frequent failures and impacts which are more difficult to remediate.

Turning back to the saying, the hammer stands for a tool (or tools) to explore the issue at hand, design policy options, deduce to what extent the policy measures will solve the issue and compare their achievements as for to find the most suitable solution - i.e. one which outperforms all the others. Almost by definition no single tool will ever deliver all knowledge needed, policy analysis require a set of tools to scrutinise the policy issue form

[1] The traditional version of the saying is “If all you have is a hammer, everything looks like a nail”.

different viewpoints and for different purposes. The range of a situations in which a single tool may be meaningfully applied is constrained by the data requirements and their availability, as well as the conformity of tools' assumptions with the conditions encountered in the practical situations. For example in order to apply cost benefit analysis (CBA) as required by the Water Framework Directive (WFD), one has to grant validity to the Kaldor-Hicks compensation principle[2] and place monetary value on environmental goods and services for which there is no market and thus no value is readily available. If the actors involved refuse such compensation or hesitate to place value on environmental benefits, the results of CBA will be of little relevance of the policy choices.

The integration of various tools or their results require even more flexibility. For example integration of ecological and economical models (Drechsler et al., 2007) require more than to choose respectable models from both domains – the integrated models need to have an interface over which they communicate – be it a spatial or temporal scale, relevant and measurable forcing variable and reference to a common set of policies. All the activities outlined here are addressed in the WP42 as enhancements and may comprise any improvement of the content, methodological background or transferability of a tool, or any other support measures which increase the users' ability to apply the tool (Mysiak et al, 2006).

The WP42 main goal is to develop or enhance tools developed elsewhere in the Newater project, required in the project case studies to pave way to adaptive techniques of water management. Surly, the adaptive management is not achievable by a single tool, not even by all tools which WP42 may possible develop or enhance. It can be achieved as a result of multiple tools, and a apposite mix of institutional arrangements and effective policies. This has been extensively addressed din the deliverable 1.1.1 (Medema and Jeffrey, 2005), 1.1.2 (Pahl-Wostl et al., 2006) and in Pahl-Wostl and Sendzimir (2005). Without compromising the conception of AM too much, for the purpose here we stress a few aspects of adaptive management which have direct implication for how tools are developed and applied: The first is the flexibility i.e. ability of a tool to respond to and provide insights about a range of different situations. The second is the reflexivity or sensitivity to how the managed is shaped by the management. Finally, the methodological plurality means that the management problems faced need to be exposed to scrutiny imparted by various tools, each of them seizing different perspective and paying attention to some aspects while disregarding others. It goes without saying that these principles are no receipts but important ingredients.

1.3 How it was decided what tools to enhance?

The fast track enhancement was defined in the deliverable 422[3], released in May 2006. The choice of the tools to focus on was based on (i) the gaps identified in the state-of-the-art report (del 421[4]), and (ii) the revealed needs of case studies (del 412[5]). Where several tools fulfilled these requirements, preference was given to the tools the WP42 partners were already familiar with and which were planned to be applied or further developed elsewhere in the project. The deliverable 422 contains the description of tools selected for fast-track enhancement and specification what the enhancement consists of. Enhancement is defined as

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[2] The principle states, that a policy is welfare improving for a society if the gainers could compensate the losers and still be better of (see e.g. Hanley (2002)

[3] Del 422: Report Specification for enhancing existing tools

[4] Del 421: State-of-the-art report with users' requirements for new IWRM tools

[5] Del 412; Report - Initial assessment of users' requirements from case studies, defining user needs for the enhancement of existing tools within NeWater

any improvement of the content, methodological background and transferability of a tool, or any other support measures which increase the users' ability to apply the tool. The specification of an enhancement consists of a list of actions, intended users and application context (envisaged purpose of the tool), and a time schedule. Moreover, a tentative content of this deliverable (del 423) is given. Besides the tool itself, it was set to include suggestions for the training (WP43), leaflets of each enhanced tool for a broader dissemination, and a progress report from a practical application of the tools in project's case studies (including a feedback from the intended users).

1.4 Work progress of the fast track enhancement

WP42 meeting in Venice/Italy, May 2 - 4, 2006

– agreement of the specification of the fast-track enhancement, adoption of the deliverable 422,
– discussion of the early development plans (see Annex 1),
–early discussion of the Newater portal,

WB4 meeting in Copenhagen/Denmark, September 11-13, 2006

– review of the development progress (slides available),
– application in case studies discussed,
– content of the highlight presentation for the NW general assembly and the market place for the enhanced tools decided,

NEWATER General assembly in Hortogaby/Hunagry, October 23- 27, 2006

– review of the development progress (slides available),
– market place presentation of the tools, extensive discussion with the stakeholders regarding the tool application/utility and further development

WB4 ad-hoc portal phone conference, December 12, 2006

– review of the plans regarding the NW plans, time schedule adopted

WB4 meeting in Osnabrueck/Germany, January 30-31, 2006

– final review of the enhanced tools (apart of the tools developed by partners who started later),
– further discussion regarding the design and development schedule for the NW portal.

1.5 What tools have been focussed on?

The enhanced tools comprise a wide variety of tools useful at various stages of the IWRM. The tools include (the abbreviations in bold are used throughout the document): The Bayesian Networks for participatory model building (**BN**); GWP Handbook supplement (**GWP Supplement**); Enhanced Stakeholder-Issue Analysis (**ESHA**); GANetXL software environment for genetic algorithms (**GA**); Adaptive Monitoring Design Support System (**AMDSS**); Guidelines for successful application of DSS (**DSS Guide**); and **Waterwise** - an optimisation, bio-economic model.

These tools are useful at different stages of the (somehow idealised) policy cycle[6]. As can be seen in the figure 1, the distribution of enhanced tools competences is well balanced: tools

[6] Stage model of policy making to large extent simplifies the policy processes, as such it has been criticised by many (e.g. Sabbatier, 2007). Here we use it to explain the different focus on the enhanced tools.

like BN, ESHA, AMDSS provide valuable insights into the management problem at hand and help to define its most salient features. Other tools such as BN, GA, WATERWISE are suitable at a later stage to assess effectiveness of policy options and to stimulate value judgements and building of consensus. Yet other set of tools (GWP Supplement, DSS Gudie) provide guidance throughout the whole policy process.

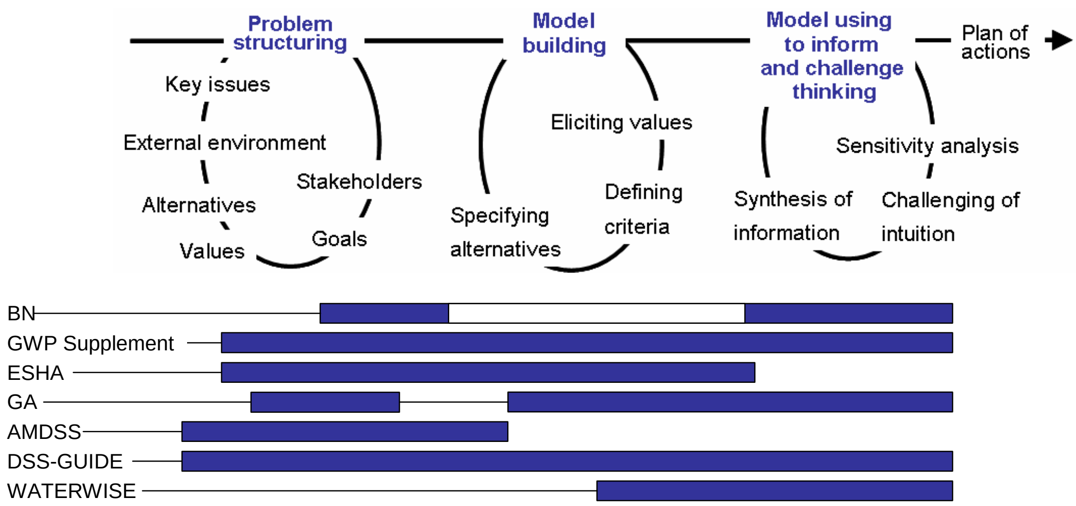

Figure 1: Distribution of tool competencies across the idealised policy stages (based on Belton and Steward, 2002).

1.6 Type and Impact of the enhancement

The WP42 partners focussed on various enhancements (see table 1) which include awareness rising and capacity building (GWP Supplement); better documentation (Waterwise, BN, GA), guidance in application of the tool (DSS Guide); novel approaches to assessment of the tool performance (BN); improving the transferability of the tool or its results (Waterwise); making the tools more flexible and applicable in context of adaptive management (ESHA, GA, AMDSS). The in-depth description of the enhancements is given in the section 2 and in the annexes dedicated to each enhanced tools.

The enhancements have been carried out in collaboration with case studies, especially with these which displayed limited capability to employ the corresponding tool and willing to make use of project resources to a cooperative specification, testing and/or application of the enhanced tools to real world management issues faced. In several cases the test/application and the further development/enhancement are continued elsewhere in the project (see table 1). For example the DSS-Guide informs the policy analysis and DSS development in the WP17 (task 175[7]). This is important because the time allocated to the enhancement exercise was not always sufficient to guarantee a successful implementation of the tools in the case studies.

[7] This task aims at development of a conceptual design of a DSS which supports the transitions towards the adaptive management regimes. It is carried out in collaboration with FEEM, IRSA and UNEXE in the context of Tisza case study.

Tool	Enhancement	Test basin	Testing and further development	Publications
BN	Documentation and ex-post assessment of MERIT guidelines and Danish BN cases	Guadiana	Continues in context of the task 154	(Henriksen and Barlebo; Henriksen, H.J. et al.; Henriksen, H.J. et al.)
GWP Suppleme nt	Integration of various learning styles and preferences in a new interpretation and delivery of the handbook	Orange (Rhine)	In the context of the WP43's Training the Trainers (TtT) workshops	
ESHA	Explanation of importance of steps. Inclusion network approach and reasons for collective learning.	Rhine and possibly Tisza	In the context of the WP43's Training the Trainers (TtT) workshops	
GA	development of pre and post processors	Guadiana and Tisza	Continues in context of the task 175	(Farmani et al., 2007 submitted; Farmani et al., 2007 under preparation)
AMDSS	Information needs elicitation to take into account the continuous changes	Tisza and Amudarya	Continues in context of the task 176	(Giordano et al., in press), Giordano et al (forthcoming)
DSS Guide	Key success factors for implementation and development of DSS	Tisza	Continues in context of the task 175	Giupponi et al. (in press), Mysiak (forthcoming)
Waterwise	Transferability, functionality, and documentation	Nile, Elbe	Continues in context of the task 174	(van Walsum and Siderius, 2007; van Walsuma et al.)

Table 1: Main enhancements focussed in the fast-track exercise and the case studies in collaboration with which the enhancement has been completed.

Besides the insights and achievements in the case studies, the fast track enhancements have resulted in a number of publications in scientific journals and conferences (see the last column of the table 1). Altogether the enhanced tools have been reported in 7 submitted journal articles and one book consider for publication, other 3 article are close before submission and several papers have been presented at conferences.

1.7 Advantages of the enhanced tools and the synergies between them

The similarities between the fast track enhanced tools regarding the aim and the type of enhancement has been described in sections 1.5 and 1.6 respectively. The table 2 and annex 1 explores the relative advantages of the enhanced tools when compared with the next-suitable alternatives (i.e. tools not addressed in the WP42 which yield similar insights but which employ different methodologies). The table 2 summarises the main advantages of the enhanced tools and explains why the application of the tools addressed in the WP42 appears superior, especially in the conditions experiences in the NW case studies. In addition, the most sensitive information are described, i.e. information which are most important for the successful application of the enhanced tool. Is this information not available, or not easy to gain, the performance of the tools will be compromised. See Annex 1 for more details.

Tool	Next alternative tool	Main advantage compared to tool in (1)	Most sensitive information
	(1)	(2)	(3)
BN	Simulation models	Combination of beliefs and new evidence; graphical representation	Populating conditional probability tables with numbers
ESHA	Cognitive Mapping and group model building	Collective learning	Perceptions and attitudes which are embedded in the wider cultural and political environment
GA	Multiple criteria decision making	Complete pay-off characteristics determined by a single optimization run	Problem frame / set-up information (boundaries, objectives …)
AMDSS	Problem structuring methods; Information cycle	Inclusion of alternative sources of knowledge, learning support	Perceptions of stakeholders and decision makers concerning information
Waterwise	Genetic algorithms	Efficiency, concentration on content	Problem frame / set-up information (boundaries, objectives …)

Table 2: A comparison of the fast track enhanced tools with the next suitable alternatives.

The synergies between the enhanced tools make it possible to apply one tool to facilitate the appliance of another tool, in some cases even to improve the later consistency. For example, the genetic algorithm have been successfully applied to examine the consistency of the conditional probabilities in the Bayesian Networks (see Farmani et al, 2007 under preparation). Furthermore, well designed participatory processes (making use of ESHA or cognitive model techniques employed in AMDSS) create positive conditions for predictive models being understood and trusted. Models which structure reflects needs and governing mechanism of policy making are likely to yield more reliable and socially robust knowledge, which in turns increases prospect of policy success. Taking advantage of these attainments, perceptive decision analysis can help all actors to understand (and represent in explicit form) values held and negotiate divergent interests.

The synergies between optimisation techniques (genetic algorithms and multiple criteria decision analysis), conceptual modelling techniques and Bayesian Networks are further explored in the task 175 which aims at developing a decision support system to facilitate the transition to more adaptive management practices. The choice of these techniques is not casual, each of them in its own right was found useful in situations for which adaptive management is most proper. They are also complementary and likely to reduce each others limitations when applied together. social cognitive maps into Bayesian Belief Networks, and how to employ the genetic evolutionary algorithms to explore the Pareto efficient options resulting from the BBN. While employing the above described methods to the case study Tisza, the team working on the task (composed by three WP42 partners) is investigating particularly following questions:

- What type of uncertainty is produced by the different tools and how likely are the different sources of uncertainties to exercise a significant effect on policy choices? How can uncertainty surrounding the application of one tool be take up/propagated by other tools, applied subsequently? How is the confidence in each tools' results forged and translated/merged into overall uncertainty assessment?

- How to assess the effectiveness of tools, each one separately or in combination, both in terms of the final outcomes and the process characteristics? To what extent is the tool assessment determined by the context in which it is applied ?

- To what extent the combination tools produce redundant information/insights and whether this redundancy is beneficial or needs to be reduced? What conditions disqualify the application of any of these tools and what alternative tools are more suitable particularly in these conditions?

2 Summary of the enhanced tools

2.1 Bayesian Belief Networks for participatory modelling

Bayesian belief network (BBN) is a graphical model consisting of nodes and directed edges. A node represents a variable with states and directed edge from node A to node B represents a cause-effect relation; it indicates that the state of A is likely to have an impact on the state of B. The strength of a cause effect relation is represented by conditional probabilities. BBN can be used to integrate environmental, economic, social, cultural and political variables. BBN also provides an excellent focus for dialogue with stakeholders which is a precondition for participatory integrated assessment. The tool can handle and interpret incomplete data sets and explore various sources of uncertainty, but fails to represent feedback loops and cannot handle temporal and spatial variations in a river basin

The tool enhancement looked at the guidelines for use of Bayesian belief networks, developed in the EU funded research project MERIT (Bromley, 2005). An ex-post evaluation by a post audit based on qualitative interview with two water managers previously involved as end-users representing the municipality of Copenhagen and the water supply company Copenhagen Energy (KE) was carried out. The water managers expressed, that the tool provided a focused dialogue and that it helped managers to evaluate different alternative actions and consequences in more depth. In the case BNs were used to make it clear to the water company that farming contracts should not be part of the Copenhagen Energy's toolbox for groundwater protection. Bayesian networks with appropriate interfaces for different users e.g. water managers, stakeholders, researchers, and public may facilitate transition to AM by the ability to visualize complexity and uncertainty in a practical way. As one of the managers expressed it in the qualitative interview: "I think the BNs could help to delineate the complexities and also handle some of the uncertainties that we are confronting, in terms of what is the value of the source of clean groundwater". But in itself BNs do not allow a safe and transparent dialogue, the safety and transparency has to be enabled by the way the tool is used, which is the nature of the complex and uncertain participatory process, where learning is of significant importance. As the result of the MERIT project, prescriptions and guidelines for constructing BNs with stakeholders involvement have been developed based on four case studies which can be used as training material for water managers in how best to interactively construct BNs with stakeholder engagement. These guidelines should be remembered and utilized when using BNs for adaptive management for participatory integrated assessment in relation to gap analysis and exploring especially multiple frames uncertainty.

As next, the capability of BBN for integrating different domains were analysed, based on another Danish example of use of the tool in an attempt to couple economic models and groundwater monitoring data. Bayesian belief networks (BN) allow knowledge and data from economic, social and hydrological domains to be integrated in a transparent, coherent and equitable way, and the paper documents that the impacts of pesticide management actions on agricultural economics and groundwater and drinking water quality, can be analysed with the overall aim of exploring complexity and uncertainties. Since the aim of integrative research is to use a range of different worldviews as the basis for a better understanding of human-environment systems where integration means the process of constructing new worldviews, Bayesian networks are especially powerful in order to provide a focused dialogue in order to construct shared, qualitative and quantitative worldviews or collaborative 'conceptual blending' of domain knowledge from which completely new ways of seeing the world and innovative solutions to problems can emerge (Henriksen et al., forthcoming / Nordic hydrology).

In a presentation for the MOPAN conference in June in Leuven aspects of social learning and reframing was evaluated (Henriksen, in press). In order to integrate factors of importance for integrated groundwater management social learning and reframing processes are important and the flexibility of BNs allow both integration of different issues and focused dialogues. However, leadership of such processes are challenging, and managers need to develop a certain capacity and structures to live with paradoxes, and to move on. They need to have the courage to listen and in the same time be creative and to participate in spite of "not being in control". A way to do this in the case study was to reflect about the case and analyse what happened in the leadership group in more depth, and by listening to the responses at the workshops, at individual meetings and by collecting written feedback by consultation. Another way was to allow the professional stakeholder group to split into smaller interest groups, e.g. to allow reframing at the edge of the temporary organisation (T-organization), when the more challenging quantitative stage was dealt with and the momentum was lost. The subsequent process of reconstructing BNs captures expressions of fixed language and shared constructed objects reflecting the current stage of the integrated understanding and assessment process.

Coupling of BNs and Evolutionary multi-optimization tools (Farmani et al., in prep.) demonstrate the possible application of the BBN-evolutionary multi-objective optimisation methodology in search for a non-dominated set of policy options. The integration of evolutionary multi-objective optimisation technique with Bayesian belief network resulted in a large number of high-quality non-dominated policy options. Attempts to find combinations of the states of key variables under the full range of management options were made possible by the integration of these two methodologies for the management problem where the choice is difficult. It can be concluded that participatory integrated assessment approach using Bayesian belief network and multi-objective optimisation technique as a decision support tool has several advantages. The main advantage of the methodology is that it allows testing of the constructed BBN and influence diagram, and inspection for consistency. Secondly, it provides a more open approach to decision making (i.e. not favouring a single position). Finally, it allows incorporation of inputs from multiple decision makers into the search and decision making process.

Finally, the tool was tested for the upper Guadiana basin in Spain. Here the BN network deals with different management actions which influence irrigation water use, the groundwater level, crop pattern, farmers' income, wetland recovery, productivity and employment in the Upper Guadiana Basin. Included among the potential action that might be taken are: (a) Acquisition of water rights, (b) Law enforcement, (c) Common Agricultural Programmes (CAP) subsidies and, (d) Annual management plans. Climate and the initial state of the aquifer are included as control factors. The indicators (objectives) in the network include: (a) Groundwater levels (b) Impact on wetland recovery (c) Agricultural productivity (d) Farmers' income and (e) Levels of employment in the basin. When running the Bn combinations of actions can be selected and calculated.

2.2 Supplement to the UN-GWP Handbook

Work has been carried out in reference to tool enhancement of the GWP Handbook, "Catalyzing Change: A handbook for developing integrated water resources management (IWRM) and water efficiency strategies". The tool enhancement specifically includes a Supplement to the current GWP Handbook, and draft 1 on this new supplement is now complete. The title of the supplement is, "Keeping Change Going: A supplementary note on adaptive water resources management (AWRM)". The enhancement/supplement includes sections on uncertainty, the complexity of human-technology-environment systems, complex adaptive systems theory, interactive components, emergent properties and unpredictability, decentralised control, and adaptive water resource management. References are still to be added.

This text based tool is accompanied by the guidelines for a social simulation and workshop in which participants take part in a role-playing game that provides them with an action-based learning experience on the topic of complex adaptive systems and their properties, and enables participants to make links between this experience, theory and their own practice. In turn participants are provided with a facilitated opportunity to extend their sense-making to the topic of AWRM and implications for practice. It is expected that participants of the social simulation and workshop will have read as pre-workshop reading material, the GWP Handbook and Supplements mentioned above.

Contact has been established with two relevant parties for the testing of the tool and subsequent evaluation: Chris Dickens in South Africa in reference to the Orange case study basin; and, the main contact at GWP in Sweden. Chris Dickens will provide links with participants for training and tool testing / evaluation purposes, and GWP will provide links with the GWP technical committee for proof-reading and review purposes of the supplement delivered.

Now that draft 1 of the supplement, social simulation and workshop guidelines have been delivered, it is intended to move on to the next phase whereby the GWP technical committee will be asked to review and give feedback on the material produced. A date needs to be agreed by when this review will be completed and all feedback sent back to Cranfield by the GWP contact on behalf of the GWP technical committee. Concurrent to this, Chris Dickens will be contacted again in South Africa and asked to provide information on participants and a timeframe and dates for implementation / testing of the tools. Evaluation protocols will now be developed for use alongside the implementation / testing of the tools.

2.3 Enhanced Stakeholder-Issue Analysis

The Enhanced Stakeholder Issues Analysis tool is a guideline on how to carry out a stakeholder-issue analysis and what to do with the results from this analysis in practice. The reason this tool was developed was because it appeared that various stakeholders in the Case Basins were aware of the stakeholder analysis approach, but were unsure what to do with the gathered information in their decision-making process.

However, unlike most guidelines, this enhanced tool builds up on existing tools for stakeholder issue analysis and is more tailor-made to the various expertise of the stakeholders in the Case Basins who have indicated that they would like further training about use and application of such a tool. The tool provides stakeholders insights in each others' goals, views and interests and shows how stakeholders can step away from assumptions about others; uncover possibilities and limitations for cooperation; uncover possibilities for change; discover differences in perspectives. Thus, one output of the tool is the gaining of new insights by the stakeholders of other stakeholders' goals, aims, interests and involvement in project activities. This is achievable since the enhanced tool includes aspects of the network approach, which provide stakeholders with techniques to assess (other) stakeholder impact and to identify manners in which to approach, deal with and work with other stakeholders.

By including instruments that will enable stakeholders to learn together in a participatory manner, another output of the tool is that the stakeholders will collectively work towards defining further strategies. Thus a collective and/or individual reflection is initiated so that stakeholders will be able to make an assessment of the insights that have been gained for the short-term. In the long-term, stakeholders will have instruments to examine and reflect upon behavioural changes, such as through use of Outcome Mapping.

The Enhanced Stakeholder-Issue Analysis tool very much fits in the same scope with tools such as cognitive mapping, group model building and also, to some extent, with multi-actor behavioural simulations and social learning. The advantage of the tool, however, is that collective learning is stimulated. This will not be done by being told something, but rather, through experiential learning and interaction with other stakeholders. The Enhanced Stakeholder-issue analysis furthermore assists stakeholders in gaining insights in the goals, aims and views and interests of the other stakeholders for achieving AWRM goals in the basin. By understanding each other's points of view and by taking these into account it will be possible to design more effective AWRM strategies.

One reason for reading this document could be to learn more about the steps of a stakeholder analysis. This can be done by reading only the “why this step” parts described in each step. Another reason for reading this document is because in this assessment, managers will become more familiar with why it could be very valuable for strategy making to have identified the following points prior to further project work:

1. the interests of other stakeholders in relation to the problem/project the team wishes to address,
2. the conflicts of interest between stakeholders which will or could effect the project,
3. the relations between stakeholders which can be built up on or will need to be established in order for the project to be successful,
4. the manners in which relation-building could be possible.

However, the analysis is not purely static nor should it be carried out only once at the start of a project. We urge readers to keep in mind that during the course of the project, some form of a stakeholder analysis should be carried out in order to monitor if there have been changes in stakeholders’ interests, conflicts of interests, relations, etc. Adjustments to strategies thus can be, and should, be made accordingly..

2.4 Evolutionary multiobjective optimisation

The evolutionary algorithm software has been enhanced by means of development of a pre-processor (to convert available information into a format acceptable by the tool) and a post-processor (to display results generated by the tool in different formats) for better exchange of information. This required development of a user friendly add-in which integrates into Microsoft Excel.

The enhancements are as follows:

– Support for integration with simulation packages: allows linking GANetXL with other simulation packages (to evaluate fitness of solutions). In order to use this functionality, simulation software must expose its API in form of DLL library or any other way that allows invoking its functions from Visual Basic for Applications.

– Suspend, resume: This allows the user to stop the optimisation process, do some changes and restart the optimisation process. This will be a very useful functionality in adaptive management (AM) where the process is iterative rather than prescriptive (development of management alternatives in the presence of available information), that can adapt as an increased understanding of the system evolves (Progressive preference articulation). The AM process involves iteration of multiple prescriptive processes.

– Multi-objective results browser: This helps the decision maker with visualisation of the all the possible options for a problem with conflicting objectives.

– Automatic saving of the population: This feature allows saving of intermediate population in user specified intervals. This is useful when performing optimisation containing multiple runs to save the population at the end of each run. Without using this option only the best organism (single objective optimisation) or Pareto front is saved to summary sheet which does not allow resuming the computation at later time.

– Backups of intermediate population: In case that the add-in crashes and Excel is closed the computation can be restored later from the backup file.

– Visualisation of results and progress: When the algorithm is running, the progress is displayed in three ways

– Progress bar: displays the overall progress of the algorithm.

– Grid: displays the values of genes, objective function, penalty / infeasibility and other statistical indicators for obtained solutions.

– Chart: displays the best Pareto front in multi-objective optimisation or just the fitness of the best organism in single objective optimisation.

– Built-in help

– User manual

– Practical examples: the tool is accompanied with number of (single and multi-objective) examples.

The software and the user manual can be downloaded from http://www.ex.ac.uk/cws/ganetxl

The enhanced tool has been used in policy analysis of two water resources management problems. This required coupling of the tool with a Bayesian belief network analyser. The integrated participatory assessment methodology based on GANetXL and Bayesian belief network tool has been discussed in details and applied to two real case studies in two journal papers.

2.5 Adaptive monitoring design support system

The guideline presented here was developed on the base of the results collected in the WP16. The main aim of the guidelines is to facilitate the integration between the policy process and the information management process. This integration is crucial in Adaptive Management.

Moreover, the guidelines help to identify alternative sources of information, while allowing a high degree of interaction with local communities and stakeholders.

Incorporating uncertainties about future pressures on river basins into water resources management sets new challenges for environmental resources management that is in the following defined as adaptive management (AM). AM involves trying policies actions, monitoring and evaluating outcomes, and selecting a basis for judging what has been learned (McDaniels and Gregory, 2004). This requires information as essential feedback to management to ensure that necessary or appropriate action is taken, despite the fact that knowledge about the system being managed may be limited. To support learning process, monitoring systems are required to provide both negative and positive feedback in the reiterative evaluation of both the continued desirability of the objectives and progress toward their achievement (Lessard, 1998). This cannot be done without the establishment of an iterative dialogue between information users and producers, which is well represented in the information cycle (Timmerman and others 2000). The cycle depicts monitoring as following from water management and feeding back to water management. It is a framework for communication between policy makers and scientists. According to this framework, the monitoring design has to be considered as an ongoing activity that influences and is influenced by management and policy. The enhancement of methodologies to support monitoring system design in AM is the aim of this contribution.

The main enhancement concerns the integration of monitoring system within the learning process which characterizes the Adaptive Management. The implementation of monitoring strategies supports two learning processes. On one hand, feedbacks to management actions are acquired supporting learning in water management as described before. This learning results in changes in the water management mental model. On the other hand, learning relies on feedbacks to applied monitoring practices. This learning process requires adaptation of the information management mental model. Revision/adaptation can occur in information needs, monitoring strategies and data interpretation due to changes in mental models. An Adaptive Monitoring Information System (AMIS) supports the learning processes both in water management and in monitoring strategies. An AMIS adopts an adaptive approach to monitoring design, which iteratively refines the monitoring design as a result of experience in implementing the monitoring program, assessing its results and interacting with the users. This observation actually describes a learning process in monitoring practices.

The developed guidelines aim to support the design of monitoring system able to support these two learning process. The guidelines are structured as following:

Step 1: Identification of stakeholders

Step 2: Establishing the purpose and scope

Step 3: Developing stakeholders mental models

Step3-1: Water management mental models

Step3-2: Information management mental models

Step3-3: Develop the interface between water management and information management mental models

Step 4: Identify indicators

Step 5: Data collection methods

Step 6: Frequency of use

Step 7: Data analysis

Step 8: Communication and reporting

Step 9: Establishing a baseline for comparison

Step 10: Update information needs and indicators

Currently, the experimental implementation of the guidelines is carrying on to support monitoring design in the Tisza river basin and in the Amudarya river basin. In the first case, the monitoring system will support the management of water stagnation. In the Amudarya, the focus is on soil and groundwater salinity

2.6 Guidance document on Decision Support Systems

This report reviews and summarises persistent issues, contested attitudes and realized attainments discussed in the DSS domain. The report illuminates reasons for the prevalent perceptions of failure and outlines best practices in development and application of DSS. The targeted audience is broad and includes policy makers, scientists and lay public. To approach such a great variety of readers, the format of this report is intentionally concise and language is, as far as possible, accessible to anyone. Throughout the report the term DSS is used as a synonymous for a wide range of other tools (e.g. planning support systems, expert systems, etc.) which may be elsewhere differentiated, sometimes for good reasons. We believe that the issue addressed in this report are to large extent similar for all these tools and the variety of meaning associated with the term DSS is seen as an advantage rather than a source of frustration.

The assessment spawn by the report is necessary for various reasons: First to improve the return of investments made in the DSS developments. Scientific projects designed to develop DSS have normally only had very limited scope to oversee the implementation and application of the DSS beyond the case studies supporting the development process. Secondly, to trigger a wider deliberation about best practices in scientific policy aid in general. This report stresses changing relationship between science and society, favouring greater openness and a dialog between all knowledgeable parties. The DSS field is in focal point of these developments.

Overarching goal of this guidance document is to raise awareness about the issues encountered when designing computerised tools for policy and regulatory decisions. The guidance contains many suggestions and practical advises which may appear obvious to an experienced user or expert. This is inevitable due to the range of addressed questions and the variety of intended beneficiaries of the guidance. In other cases the strategies to deal with the identified issues are only sketched out and not handled in sufficient detail, the readers are referred to other documents and reports instead. Again, the document does not provide recipes for success, nor it is reasonable to expect them. Although the ingredients of such recipes are known (e.g. early end users involvement or in-built flexibility of systems to accommodate changes), their exact dosage (quantity and quality) is to large extent context dependent. What has worked out in one context is no definite guarantee for a success in a different context.

Yet the main criticism expressed by some reviewers regards the lack of recommendations, both for research and policy, about what should be done about the low uptake of DSS for practical policy making. To reply to this critique we recall the difference between a policy brief and a policy recommendation. The aims of the former is to name the issues and link them to a set of probable drivers. This is precisely what the present document imparts: point out the challenges and raise awareness. The latter (policy recommendation) goes beyond and provides an in-depth analysis of options to address the identified issues. The evidence assembled in this report is not sufficient to back the policy options. Besides, policy recommendation presume a body which has the authority to make decisions to fix the issue in play. In our case the success of DSS is the result of an interplay of a number of actors.

Finally, most of the issues discussed here are not limited to DSS field and upset science-policy interface in general.

Although it is the awareness and nor concrete policy recommendation what this report aspires at, it does convey practical advises what to care for and for what reason. The section seven, the guidelines, provides a checklist or to-bear-in-mind caution which is appropriate for any effort to employ formal models and computerised tools in course of policy making.

2.7 Waterwise model

The ‘Waterwise’ model is a bio-economic mathematical programming model that covers regional hydrologic interactions, effects of land use on water quality, effects on agriculture, and effects on nature. The model is ‘fed’ by results of computational experiments using simulation models, including MODFLOW (groundwater)-SIMGRO (top system including unsaturated zone)-SOBEK (surface water)-ANIMO (nutrient leaching)-Cascade (nutrient retention in surface water.

For instance, ‘micro-buffering’ in the upstream areas is simulated by SIMGRO (or another simulation model) by introducing small culverts in dammed-up ditches. The effect on the peak discharges is then determined (in the example roughly a 20% reduction) and included as a coefficient (of a land and water use option) in the matrix of the Waterwise model. For each possible measure the consequences of nutrient leaching are also stored as coefficients. The Waterwise model contains the structure of a basin network in the ‘constraint section’ of the model matrix. Hence a summation of the nutrient load coming from the upstream subcatchments can be made. Retention of nutrients in the surface water system has so far not been taken into account. For the processes in groundwater (transport and denitrification) a mixing-cell model is embedded in the matrix of the optimization model.

Even though the incorporated sub-models are simplified, the ensemble of relationships can include dynamic spatial interactions, like between upstream inflows and downstream water levels in the form of simplified response functions. By embedding these descriptions in a mathematical programming model it is then relatively easy to make the connection with models of the other strata (i.e. that of networks and occupation). Through this form of vertical integration it then becomes possible to make the two-way connection with other planning principles that should play a role for the development of a region. It is also at these other strata that some of the envisaged multi-functional land use (i.e. recreation) becomes manifest. The land use should also be valued in that context. The Waterwise approach thus combines the horizontal integration within the water system and the vertical integration with the other planning strata. Then decisions can be based on an overall judgment by policy makers. Water serves as one of the guiding principles, but is not necessarily the dominant one.

Subsequently, the Waterwise model minimizes the loss of agricultural income. In the example, the model chooses to convert a substantial amount of agricultural land to new nature areas in the form of new natural grasslands and new forest. The new natural grasslands are positioned around the existing natural grasslands in order to have a beneficial effect, according to the ‘positioning principle’. In this case there is synergy between the compatible functions. The same applies to the extensive grassland (low intensity agriculture). The new forest is beneficial for reducing nitrogen loading and also for reducing the peak flow. This is due to the increased evapotranspiration, which leads to lower groundwater levels, thus providing more storage capacity at moments with high rainfall. Forest thus increases the natural buffering capacity. The increased evapotranspiration is, however, not beneficial for the wet nature areas. For this reason the model has placed the new forest away from the existing natural grasslands (which is an example of ‘antagonistic’ functions and the positioning principle). Whereas a general nitrate reduction in order to meet the WFD limits would reduce the income of all farmers under a minimum level, the model finds a more sophisticated solution by determining those areas where a sufficient (from an agrarian point of view) amount of nitrate may be dispersed with the least effect on the entire system. It turned out that the optimization model can achieve the same WFD-goal at 40% less cost.

The following activities have been undertaken for enhancing the code:

- components that are typical for only the Netherlands have been removed or made generic;
- a time dimension has been added to the flow simulation; this is needed for applying the model to large catchments that do not have an immediate response like was the case with the Beerze & Reusel catchment;
- the network representation of waterways has been made more elaborate, with water balances for both the connecting nodes and for the links; the flows in the network links can now be modelled in two alternative ways:
    - with the unit hydrograph method
    - with a reservoir water balance simulation.
- binary decision variables can be used for including the existence of links as part of the optimization process; the adding of links in a network is seen as an important component of increasing the adaptive capacity;
- all input files have been made into ‘lists’, which is more flexible than tables;
- the preparatory work (streamlining of the code) has been done for including multiple events in the model; these multiple events are seen as a way of implementing a risk management strategy aimed at increasing the adaptive capacity of a system;
- a documentation report has been assembled, including 5 sections:
- a demonstration data set has been extracted from the application to the Beerze & Reusel region.

The current consolidated code is suitable for application by other parties than the developer. For the developer it is a comfortable starting point for future enhancements.

3 Outlook

Following the fast-track enhancement exercise and taking benefit of the collected experiences, until the end of the project the WP43 will engage in the development of the new tools or enhancement of tools developed elsewhere in the project (especially methodologies being developed in WB1 and WB2). The selection of tools to focus on in the next stage of the project will be informed by (a) the evolving framework for the transition to adaptive management (WP17), (b) in parallel, the continuing evaluation of the existing and interim tools (as part of WB3), will be used to identify any further modifications/improvements that may be required, and (c) finally, taking into account the assessment of the needs for new tools which has been undertaken under Task 4.1.3.

The selection of the new tools is easier if the fast track enhanced tools and tools developed elsewhere are confronted with the double loop policy diagram (see figure 2) developed in the WP17.

Figure 2: The double loop policy diagram developed by WP17 (version as of May 30th, 2007 presented during the WB4 meeting in Venice).

The double loop diagram (both the traditional and the new learning part) suggests a series of steps one can influence by choices, in some cases the subsequent steps are results of these choices (e.g. reframing succeeded – step 10). The activities do not necessary correspond to single tools: some activities can be carried out with single tools, others only by an application of several tools together. For example Step 11 – *Create Vision* **-** may be achieved for example by brainstorming meeting or Delphi method or any combination between them. Arena initiation (step 9) may require, for example, that the potential actors are identified first, level of interaction between them (coalition or competition) scrutinized and finally only actors involved whose contribution is deemed pertinent for the issue at hand. Here the way in which the issue is framed cannot be separated from the identification of relevant actors: correspondingly, one has to apply different tools to complete the task. In this context, the contribution of WP42 can be:

(i) to compare different tools in terms of their contribution to the single task/steps in the double loop diagram and develop guidance facilitating the choice of one of them in specific situation; or

(ii) to investigate how a specific combination of different tools can help to carry the tasks in a way to explore different perspectives and gain insights which cannot be delivered by a single tool.

These choices are not mutually exclusive in principle and can be combined, the limiting factor here are the remaining resources (person months), expertise of the WP42 partners and usefulness for the toolbox.

The specification of the new tools to be developed/enhanced will refer both to the format of tool delivery and the accompanying documentation including report from practical applications, when appropriate. The specification of the further development/enhancement will most likely base on similar aspects as the fast track enhancement (see section 1.3). A new evaluation aspect of the tools will include the identification of generic and site-specific features/limitations of the tools being considered, which will be further elaborated in the Compendium from the NW Case studies developed in the WP41 (deliverable 413).

The enhanced/newly developed tools will be assembled in a consistent ‘toolkit’, in which a range of different tools and approaches will be packaged or consolidated with associated guidance and decision support facilities that meet the stated needs of the case studies. This toolkit represents a important component of the Newater portal, developed as a compatible counterpart of the WISE RTD portal to promote water resource management and to disseminate the results and experiences collected in the NeWater project. Since the WP42 cannot deliver enough tools to justify a new toolbox, the toolbox/portal should draw upon all tools developed, enhanced or used in case studies in course of the project. Thus besides the tools developed in WB1/WB2 and further enhanced/”packaged” in WB4, the portal will consists of the experiences from case studies, sample data collected within the NeWater project, the training modules developed in the WP43/WB6 and compendium produced in the WP41. The WP42 recommended that all tools intended for the toolbox/portal should be reviewed by independent committee with members form the WB4 and other relevant WPs/WBs. The final review criteria are relevant also for the choice of tools to focus on in WP42. If one can reasonably expect that the tools, although identified as potentially worth to be enhanced/developed, will unlikely meet the criteria for inclusion in the toolbox, than these tools should not be selected in first place. Specific focus on the toolbox/portal and what is expected from it needs to guide the selection of the tools, specification of the enhancement and the design of the application example.

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5 List of Annexes

Annex 1: Comparison of the tools enhanced in the fast track exercise with next suitable tools yielding similar insights (Del 423 Annex 1.pdf)

Annex 2: Highlight from the fast track enhancements – presentation from the NW General Assembly 2006 (Del 423 Annex 2.pdf)

Annex 3: Supplementary material to BN enhancement: (i) Merit guidance (Del 423 Annex 3a.pdf), and (ii) Full enhancement report (Del 423 Annex 3b.pdf)

Annex 4: Supplementary material to GWP Supplement enhancement: (i) Keeping Change Going: A Supplementary Note on Adaptive Water Resources Management (Del 423 Annex 4a.pdf); and Understanding Complex Adaptive Systems for AWRM: A Social Simulation & Workshop (Del 423 Annex 4b.pdf)

Annex 5: Supplementary material to ESHA enhancement: (i) Methodological instruction about how to apply the Enhanced Stakeholder-Issue Analysis" (Del 423 Annex 5a.pdf); and (ii) the IAP2 public participation toolbox (Del 423 Annex 5b.pdf)

Annex 6: Supplementary material to GA enhancement: (i) software GANetXL 2006 (Del 423 Annex 6a.zip[8], downloadable also from http://www.ex.ac.uk/cws/ganetxl); (ii) GANetXL User Manual (Del 423 Annex 6b.zip); and (iii) Full enhancement report (Del 423 Annex 6c.pdf)

Annex 7: Supplementary material to AMDSS enhancement: Full enhancement report (Del 423 Annex 7.pdf)

Annex 8: Supplementary material to DSS Guide enhancement: (i) DSS Report (Del 423 Annex 8a.pdf); and (ii) Full enhancement report (Del 423 Annex 8b.pdf)

Annex 9: Supplementary material to Waterwise enhancement: (i) Waterwise software demo version[3] (Del 423 Annex 9.pdf); and (ii) Full enhancement report (Del 423 Annex 9b.pdf)

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