Current Results Of The EC-sponsored Catchment Modelling (CatchMod) Cluster

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EXTENDED ABSTRACT

In 2000, the European Parliament and Council passed the directive 2000/60/EC establishing a framework for Community action in the field of water policy, known as the Water Framework Directive. It aims to deliver 'good ecological status' for all rivers through the adoption of basin-based Integrated Water Resources Management. Identifying and implementing a programme of measures, encapsulated in River Basin Management Plans, will achieve this.

To support the Water Framework Directive implementation, much research has been commissioned at both national and European levels. CatchMod is a cluster of these projects, which is focusing on the development of computational catchment models and related tools. Models are seen as essential for evaluating the various possible programmes of measures. However, the Water Framework Directive creates new challenges for modellers, particularly because it requires models not only to represent individual processes from many domains but also how they interact. Some projects, therefore, target the development of frameworks for model linking, while other projects aim at specific issues such as 'transboundary challenges', 'participatory tools', transitional waters and climate change effects. A Concerted Action promotes collaboration, disseminating results and active use during the implementation. CatchMod is co-funded by the European Commission's Directorate General Research.

This paper presents an overview of the results of the CatchMod cluster to date.

Based on the result it is clear that the joint CatchMod projects have addressed a large number of issues in integrated modelling. Due to the parallel execution of the projects, the results do require further integration. This integration is picked up in follow-up projects, in which many researchers from different projects have joined forces. Separate initiatives are brought forward to achieve true integration. This largely would not have happened if key partners of various projects hadn’t gotten the chance to meet, discuss and learn about the broadness of European research.

Now that almost all the results are available, Harmoni-CA will facilitate discussions on the various products, providing crosscutting state of the art with advice to further integration and use within the WFD implementation.

1. INTRODUCTION

In 2000 the European Parliament and Council passed the directive 2000/60/EC known as the Water Framework Directive (WFD; European Commission, 2000). The key objective of this law is to achieve 'good ecological status of Europe's water resources'. Participatory development of cost-effective River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) by 2009 is a key requirement.

The European Commission's Directorate General Research co-funds a catchment-modelling cluster of projects (CatchMod) that focuses on supporting the WFD implementation. The CatchMod research projects cover a wide range of topics within modelling for integrated water management. The issues the projects deal with vary from specific water issues (for examples the effect of climate change on lake-ecology) to crosscutting issues such as uncertainty and model linkage. One project (HarmoniCA) is a concerted action. Its purpose is first of all to bring together and synthesize available ready-to-use knowledge on the use of computer-based tools in integrated river basin management (IRBM). Secondly, the concerted action aims to bridge the gap between the 'research and development' community and the user communities.

The objective of this paper is to provide an overview of the results of the CatchMod cluster. The project results are framed in a simple scheme for the participation planning process (PPP; chapter 2). After the presentation of the results of individual projects, conclusions are drawn on the overall results and collaboration achieved.

2. A SIMPLIFIED PARTICPATORY PLANNING PROCESS (PPP) SCHEME

Many papers are available on IWRM, and PPPs in water management. Conceptual frameworks such as the DPSIR (European Environment Agency, 1999) and Participatory Integrated Planning (Castelletti and Soncini-Sessa, 2004) help to guide the development of RBMPs. The EC, through its Common Implementation Strategy (CIS) has prepared guidance documents, one of which specifically targets Best Practise in River Basin Management (CIS, 2003). More recently, Rekolainen et al. (2004) presented a conceptual framework for identifying the need and role of models in the implementation of the WFD, adapting the DPSIR approach to the WFD philosophy.

For the purpose of this paper a much-simplified description of the PPP is used (figure 1). In general, such a process consists of a closely inter-

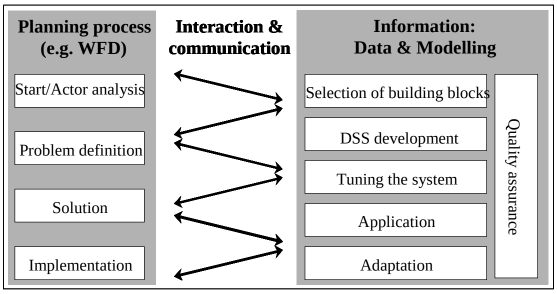

Figure 1. A simplified representation of the PPP.

linked 'planning process' path and an 'information delivering' path. In a real-life situation the process is obviously more continuous and iterative as new problems emerge, redefinition of problems is required and/or new solutions become available during the planning process. At all stages of the planning process stakeholders need to be involved. Furthermore, all steps require information that is tailored to the needs of the phases of the PPP, thus towards different types of stakeholders with different levels of knowledge. In complex situations such as integrated river basin planning, this means that very specific expert knowledge needs to be integrated and translated into understandable information for non-specialists. To achieve this, multi-disciplinary teams of scientists need to collaborate and integrate different sources of information and knowledge, such as observation data, results of state assessment models and predictive models.

This multidisciplinary process, including stakeholder participation frequently leads to the development of a Decision Support Systems (DSS). Such a DSS consists of different building blocks, and contains for example data, models and expert rules. Selecting the right building blocks, putting them together and scientifically tune them is a very complex task, and transparency and quality assurance require major resources. Especially in a complex process as the WFD implementation, it is expected that there is a need for adapting such systems during the planning process, depending on new interests, information requirements and proposed solutions (measures) of the stakeholders. It is also believed that these systems may be quite large, involving tools for many water domains and participatory purposes. A hardwired 'whole WFD system tool' applicable throughout Europe is not feasible, nor desirable. Furthermore it is usually beyond the available resources, doesn't make good use of existing models and doesn't provide the flexibility to try alternative models of individual processes, hindering the uptake of new scientific insights.

For the implementation of the WFD the time to develop the 1st RBMP is very limited. As a result, there is a need to design and organize the knowledge, methods and tools and put effort in promoting the use of research results.

3. RESULTS FROM INDIVIDUAL RESEARCH PROJECTS

This section contains the individual results of selected CatchMod research projects. The first projects have a very generic character to any modelling effort. Via projects focussing more on decision support and participation, and topical projects concerning climate effects and temporary waters, the last project concerns a full-scale study on the Tisza River.

3.1. HarmonIT - IT Frameworks (2002-2005, EVK1_2001-00037, www.harmonit.org)

In recent years much work has been done to find a generic plug-and-play method of linking models. Recently, technological advances have removed some of the obstacles and the political imperative has required a new attempt to solve the problem. The objective of the HarmonIT project is to develop, implement and prove a European Open Modelling Interface and Environment (OpenMI) that will simplify and formalize the linking of models and hence allow catchment managers to explore the likely outcomes of different policies in a more time and cost effective manner. To be economically viable, the integration mechanism must allow both existing and new models to be connected. With respect to the simplified PPP shown in figure 1the project supports easier and quicker development of DSSs. HarmonIT has now developed a successful first version of the OpenMI. The main ready to use deliverables are:

1) The OpenMI Standard interface specification to be found on www.openmi.org
2) The OpenMI Environment (.Net) - The software is released under Lesser GPL license conditions and is available on www.sourceforge.net\project\openmi.
3) 20 to 30 OpenMI compliant models and tools.
4) The OpenMI guidance and documentation.

3.2. HarmoniQUA - Harmonising quality assurance in model based catchment and river basin management (2002-2005, EVK1-CT-2001-00097, www.harmoniqua.org)

When using models and complex modelling systems, quality assurance is a major issue. Especially in a WFD setting, where participation is required and DSSs are anticipated to be more and more complex, transparency and quality are essential. HarmoniQuA's results improve the quality of modelling studies and thus enhance the confidence of all stakeholders in the use of models. With respect to the simplified PPP shown in figure 1 the project supports transparent and high-quality multi-disciplinary modelling. To achieve the objective the project has developed:

1) Generic, scientifically based quality assurance guidelines for modelling studies in an ontological knowledge base (Scholten *et al*., 2005)
2) A glossary, including domain specific interpretation information
3) The MoST (Modelling Support Tool) software tool, which implements the guideline for active use by multidisciplinary teams. (Freely available at http://harmoniqua.wau.nl/public/Product/software.htm)

3.3. HarmoniRiB - Harmonised techniques and representative river basin data for assessment and use of uncertainty information in integrated water management (2002-2006, EVK1-2002-00109, www.harmonirib.com)

In several sections of the WFD document, uncertainty is addressed (Blind and de Blois, 2003). In addition, most of the WFD guidance documents, being more specific than the WFD document itself, explicitly emphasise that uncertainty analysis should be performed. However, in spite of strong recommendations to consider uncertainty aspects the guidance documents do not include recommendations on how to do so. The overarching objective of HarmoniRiB is to advance and operationalize knowledge on uncertainty and uncertainty propagation, taking into account both data and model uncertainties. As uncertainties appear at all steps in the PPP, the project aims to support virtually all of the data and modelling boxes shown in figure 1. The main outputs the project delivers are:

1) A common terminology and taxonomy for characterising uncertainty (Klauer and Brown, 2003; Refsgaard et al., 2005a).
2) A web-based database that can hold all types of WFD /modelling data including associated uncertainty models (available on request).
3) Public datasets of eight selected basins for research purposes (available soon).
4) A tool (Data Uncertainty Engine – DUE) and associated guidance to assess, handle, propagate and analyse uncertainties in data and models (available on www.harmonirib.com).
5) Eight case study reports as proof of concept.

3.4. EUROHARP - Towards Harmonised Procedures for Quantification of Catchment Scale Nutrient Losses from European Catchments (2002-2005, EVK1-CT-2001-00096, www.euroharp.org)

The enrichment of freshwater (eco) systems with nutrients is acknowledged as an important problem to reach the WFD objective. Any management strategy must be targeted at the main sources of nutrient pollution, which requires an evaluation of the relative contribution of point and diffuse sources and dominant transport. However, the contribution of diffuse nutrient losses caused by agricultural activities is not yet well understood and the relative merits of different quantification methods have not been well defined. In EUROHARP, a detailed intercomparison of modelling approaches has been performed. The methodologies involved differ profoundly in their complexity, level of process representation, and data requirements. With respect to the simplified PPP shown in figure 1 the EUROHARP project mainly contributes to the proper selection of models, but also provides new insights in the other steps of the information delivery process. The key results of EUROHARP are:

1) A literature review of quantification tools for the assessment of nutrient losses at catchment scale (Schoumans and Silgram, 2003).
2) A data management system (access permission required), which contains all harmonized input and result data to the tools.
3) A toolbox that supports selection of tools and inspection of tool performance. (http://www.euroharp.org/toolbox)
4) Validated protocols for nutrient quantification tools testing and intercomparison.
5) A report on parameterisation, calibration and performance assessment methods used in the EUROHARP project (Silgram and Schoumans, 2004).

3.5. Mulino - Multi-sectoral Integrated and Operational DSS for sustainable use of water resources at the catchment scale (2000-2003; EVK1-2000-22089; http://siti.feem.it/mulino)

The Mulino project developed a DSS Tool (mDSS) that assists water authorities in the WFD implementation. Specific aims were improving the quality of decision making and achieving a truly integrated approach to river basin management (Giupponi *et al*., 2004). By supporting the integration of socio-economic and environmental modelling techniques with GIS functions and multi-criteria decision aids, the MULINO methodology and the mDSS software are specifically designed to support participatory river basin management planning, where choices between different options need to be made. With respect to figure 1 focus lies on the solution selection and interaction with the experts. The main results of the project are:

1) The standalone mDSS tool, freely available at http://siti.feem.it/mulino/download.htm. Besides in the project's eight case studies other applications are known in 13 other studies.
2) Multilingual guidelines, tutorials, manuals, and English background information and research results.

The MULINO approach is still under development within the framework of other research projects. The fourth version of the mDSS will be released in the second half of 2005, with various new features, including OpenMI interface

3.6. HarmoniCoP - Harmonizing Collaborative Planning (2002–2005, EVK1-CT-2002-00120, www.harmonicop.info)

The aim of the HarmoniCoP project is to increase the understanding of Participatory River Basin Planning. Within the tool-oriented scope of this paper, HarmoniCoP aims to complement the literature on information and communication technology and on public participation methods by focusing on the role of information and communication tools as a facilitating mechanism to support the social learning dimension of public participation. It should be pointed out that the project is much broader. With respect to figure 1 the project focuses on 'Interaction and Communication' in general and supporting tools in particular. The project delivers:

1) A review of twenty participatory tools ranging from questionnaires, via role-playing games to integrated assessment models. (Maurel, 2003).
2) Criteria to select the most appropriate tools and methods to support a specific participative process. These will be part of the HarmoniCoP-handbook (released in Oct. 2005).

3.7. TRANSCAT - Integrated water management of transboundary catchments (2003-2006, EVK1-CT2002-00124, http://www.transcat-project.net)

Integrated water management in transboundary catchment areas in Europe is among the major issues to be addressed in the implementation of the WFD. The main objective of TRANSCAT is to support borderland regions by developing an operational and integrated DSS. Key requirements are multilingual support, interactive visualisation interface and the possibility of plugging in numerical models, particularly of the cross-border water resource system. With respect to the PPP (figure 1), the project supports both the full path of information delivery and the interaction to the planning process. In summary the TRANSCAT project delivers:

1) A multilingual, web-based DSS (TDSS) for each case study consisting of many stand alone facilities and models (http:// transcat.vsb.cz/new/). It is composed of three essential kinds of elements: (i) Simple and complex decision support tools, amongst others Mulino's mDSS; (ii) a core system, including data serving and interfacing functionalities; (iii) a suite of models (e.g. HEC-HMS, MODFLOW, etc.).
2) The 'TRANSCAT Compendium', a report summarising the results and lessons learned.
3) A database of information collected in each case study.

The TDSS is a flexible system in which all elements can be used as self-standing entities. A concrete TDSS implementation can easily be configured according to the needs of a new case study.

3.8. CLIME - Climate and lake impacts in Europe (2003-2005, EVK-CT-2002-00121, http://clime.tkk.fi)

If present trends continue, limnologists believe that changes in the weather will have a major effect on the quality of water in lakes throughout Europe. The Clime project aims to quantify these effects by: (i) Developing and testing water quality models that can be used to simulate the responses of lakes to future as well as past changes in the weather; (ii) Developing methods to quantify sensitivity of the lakes to local, regional and global-scale changes in the weather.

Concerning the implementation of the WFD and the PPP depicted in figure 1, the Clime project develops methodologies and tools relevant to long term planning, the improved understanding of key processes, the refinement of models and strengthening the scale-dependent links between climate, lake and catchment modelling. The following products are soon ready to use:

1) A set of high-resolution climate scenarios required to drive the lake and catchment models.
2) The monitoring results of instrumented sites (to be published in autumn 2005).
3) Analysis results of the changing frequency of different weather types that quantify the impact of extreme weather events on the dynamics of lakes.
4) Improved models such as (i) PROBE–'PROgram for Boundary layers in the Environment', a 1D physical lake model and (ii) GWLF–'Generalized Watershed Loading Function'. A summary of their applications in CLIME will be published in 2006.
5) A Bayesian decision support tool, to be demonstrated in autumn 2005. The CLIME-DSS is based on Bayesian logic. It illustrates the projected changes in the European climate and highlights the expected effects on lake water quality. New 'probabilistic' methods can be used to quantify risk and to estimate the costs of managing water in a warmer world. The DSS allows the user to find the location in Europe where the future climate most resembles the current climate at another location.

3.9. TempQsim - Evaluation and improvement of water quality models for application to temporary waters in southern European catchments (2002-2005, EVK1-CT2002-00112, www.tempqsim.net)

In semi-arid areas, temporary waters are a widespread phenomenon. During their 'hydroperiod' both water quantity and quality often pose major problems. The general aim of the project is to support the efficiency of the integrated water management in Mediterranean and semi-arid river catchments by improving existing tools. To meet the objectives the project incorporates the special dynamics of ephemeral and temporary waters in existing in-stream water quality models. In terms of the PPP (figure 1), the project fills knowledge and modelling gaps for the specific situation of temporary waters. TempQsim key (expected) results are:

1) Datasets on temporary waters (available on request).
2) Improved SWAT, including additional land-use types (crops). In close contact with the Spatial Science Laboratory (Texas) input has been given to future enhancements.
3) The PESCAS model that identifies areas at risk to erosion has been improved (e.g. fractioned sediment transport) and coupled with the instream module of the CASCADE model.
4) A new river network module - the tempQsim-module – has been developed. This module includes processes like transmission losses, in-stream pool formation as well as extended features for particulate matter transport.
5) The RS-tempQ model focuses on the expansion-contraction of the inundated area of riv-

ers and describes the impact which hydrologic, sediment transport and biochemical processes have on temporary river dynamics.

3.10. TISZA RIVER PROJECT - Real-life scale integrated catchment models for supporting water- and environmental management decisions (2002-2004, EVK1-CT-2001-00099, www.tiszariver.com)

The general objective of the completed Tizsa River Project (TRP) was to save and secure the water resources and ecological values in the TISZA Basin. The scientific objective was to develop a 'real-life scale' integrated catchment model system, consisting of application-oriented tools that are exactly tailored to the issues to be solved and the availability of data. Thus, the TRP put the primary emphasis on developing the 'Information' component of the PPP (see figure 1). The role of the information is to support the envisaged WFD-based planning. The key results of the project are:

1) Models developed for and/or adopted to the Tisza River Project, which include hydrological, hydraulic, water quality, ecosystem and other model-like calculation tools (amongst others: Hec-RAS, WetSpa, SensMod, etc);
2) An international database accessible via the web-based Tisza River Information System TRIS. This system is operational.
3) A set of ecological, chemical and (eco-) hydrological measurements and data evaluation results that stemmed from an intensive field programme of a large number of wetlands.
4) An evaluation of the state of the wetlands and analysis of novel approaches to revitalisation.
5) The overall achievement of the project is the DSS that allows predicting the likely effects of various natural and man-induced processes.

4. RESULTS FROM THE CONCERTED ACTION HARMONI-CA (2002-2007, EVK1-CT-2002-2003, WWW.HARMONI-CA.INFO)

Harmoni-CA (Harmonised Modelling Tools for Integrated Basin Management), is a concerted action that aims at synthesizing available knowledge to support the use of ICT-tools in implementing the WFD. Harmoni-CA aims amongst others to develop overarching, broadly supported harmonized synthesis reports on various aspects of using ICT tools in the development of Integrated RBMPs. For this purpose, it involves participation beyond CatchMod research. Since the products need to be useful for the WFD implementation, much involvement of WFD representatives (policy makers and people responsible for actual implementation) occurs. Currently available results are amongst others:

1) Improved understanding and communication between researchers and European representatives of the implementation of the WFD. These improvements will soon be made tangible by a web portal, which links ready-to-use results of research to the WFD implementation process.
2) A (meta) toolbox on ICT tools has recently become available, and uploading of information is ongoing (www.harmoni-ca.info/toolbox). Also, a project database containing more detailed research project information is available. Registered users can directly access all facilities on the website.
3) A scientific guidance document on the implementation of IWRM, focussing on the role of tools.
4) A report on data assimilation and remote sensing is available on the Harmoni-CA website. Activities are ongoing to identify other useful modelling-monitoring tools.
5) Four workshops invited both water managers and tool developers to discuss and exchange on requirements for tools in participatory processes or the interaction of agriculture and water management. Results can be found on the website.

5. CONCLUSIONS & DISCUSSION

The CatchMod cluster has and is producing a huge amount of results. Much of the knowledge is encapsulated in software. The different projects target all different aspects of the PPP shown in figure 1. The clustering of the projects resulted in increased interaction and knowledge exchange between the ongoing projects. Since projects were running in parallel and were bound by their work plans, the increased interaction has not yet materialized very much, for example there is no common database, no models have actually been exchanged etc… . Highlights are the use of the OpenMI in the Mulino DSS, and the use of the Mulino DSS in TransCat. Very explicitly, representatives from HarmoniCoP reviewed the Modelling support tool (HarmoniQuA) from the perspective of collaborative planning processes and social learning. Much more exposure of results has been achieved through various technical workshops and workshops with representatives of the WFD implementation. Many researchers have taken the opportunity to share results at early stages.

As a result of CatchMod many researchers of different CatchMod projects are now collaborating in joint projects. Separate initiatives are brought forward to achieve true integration. This largely would not have happened if key partners of various projects hadn't gotten the chance to meet, discuss and learn about the broadness of European research.

Now that almost all the results are available, Harmoni-CA will facilitate discussions on the various products, providing crosscutting state of the art with advice to further integration and use within the WFD implementation.

CatchMod is an open cluster. New projects have joined the cluster, facilitating information exchange and collaboration for the coming years.

6. ACKNOWLEDGEMENT

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