From science to practice in implementing the European Union's Water Framework Directive

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The Water Framework Directive (WFD) of the European Union aims to achieve a 'good' status for all inland and coastal waters by the year 2015 (EC 2000). The directive defines how this should be achieved through the establishment of environmental objectives and ecological targets.

Successful implementation of the WFD requires integration into already existing national legislation and a sound combination of issues on technical feasibility, scientific knowledge and socio-economic aspects requiring intensive stakeholder involvement. This calls for appropriate tools such as models to support management of technical and social aspects of different phases of the implementation (Rekolainen *et al.* 2003; Quevauviller *et al.* 2005). It is therefore necessary to provide an overview of already existing methods and tools and develop new ones. Research programmes funded by the European Commission (EC) often address issues of current interest for practitioners, such as the Fifth Framework Programme, where a number of research projects to support the practical implementation of the WFD were initiated under the theme 'Energy, Environment and Sustainable Development'. The funding part (the Directorate-General for Research, DG Research) and the responsible authority for the WFD at European level (Directorate-General of Environment) saw the need to cluster these research projects and related activities, and initiated the *Harmoni-CA* project, a so-called 'Concerted Action' (i.e. Harmonised Modelling Tools for Integrated River Basin Management).

The objectives of this paper are (a) to briefly describe the overall purpose of the *Harmoni-CA* project and some of its overarching outputs, and (b) to further illustrate how the implementation of the WFD can be enhanced by combining monitoring and modelling disciplines and by bringing practitioners and researchers together.

Harmoni-CA

The *Harmoni-CA* project started in October 2002 and concluded with a major conference in Brussels in September 2007. The main objectives of the project were: (1) to build a bridge from research to practice; (2) to create a forum for related research projects to exchange ideas, to optimise and co-ordinate activities in ongoing research projects, and to initiate new spin-off projects; and (3) to gather already existing information, experience and research on both national and European levels that can support the implementation of the WFD (Arnold *et al.* 2005).

Bridging research and practice

A central activity of the project was to bring practitioners and researchers together at a large number of targeted workshops and open annual conferences. The main purpose was to open the floor for discussions on the needs of those working with integrated water management and the related outputs from the scientific community. Several opportunities and new ideas arose from the workshops. However, obstacles and bottlenecks were also recognised, such as insufficient dialogue between the scientific and policy-making communities due to different interests and languages, lack of translation of scientific outputs into tools readily applicable to policy-makers, and the lack of a structure within which the groups responsible for the implementation of the WFD could be brought together with the scientists (Arnold *et al.* 2005).

While the open annual conferences had broad themes, the workshops concentrated on the following tasks of *Harmoni-CA*: (1) establishment of a 'tool box' to provide easy and guided access to information and communication technologies for the development of river basin management plans (van Griensven & Vanrolleghem 2006); (2) development of a generalised methodological framework for harmonised model support in integrated river basin management (Hattermann & Kundzewicz 2006); (3) better integration between monitoring and modelling in water management (Højberg *et al.* 2007a, Jørgensen *et al.* 2007); and (4) investigation of how the science–policy interface can be bridged in current water management (Borowski & Hare 2007). More than 20 targeted workshops addressing these issues were held, resulting in workshop reports, synthesis reports and *Harmoni-CA* guidances.

Forum for research projects

The activities in *Harmoni-CA* and other related research projects were integrated in a cluster called CatchMod. The projects in this cluster produced outputs that could support the implementation of the WFD in different ways. This co-ordination of research and technology development activities supported researchers in exchanging ideas on modelling tools to support the WFD. It aimed to increase the output and benefit of ongoing research, to speed up the (re-)use of developed products, to avoid major overlaps between projects,and to reduce the risk of duplicating activities. *Harmoni-CA* achieved this by, amongst other things, organising two technical CatchMod workshops for the projects involved, where a dialogue was established among the scientific communities and gaps were reduced between different research disciplines. The workshops were also often used as an instrument to prepare input to guidance documents and synthesis reports.

Support to the implementation of the WFD

Another important task of the project was to collect already existing knowledge on issues related to the different steps of the WFD. This was partly done by producing a number of reports and guidances and partly by establishing a web portal.

Synthesis reports and guidances. A large number of synthesis reports and guidances was initiated by *Harmoni-CA*. The following groups can be distinguished: (1) Reports supporting modelling activities and development, e.g. quality assurance, sensitivity analysis, and decision support development; (2) Reports supporting the collaboration between different scientific/policy fields such as monitoring, modelling, agriculture, economy and (3) Reports on the science–policy interface and end-user involvement. The reports harmonise available knowledge, provide added value by picking up recent insights and are essential in order to improve the quality of communication between science and practice. Most of the reports have been commissioned to small task groups consisting of both scientists and end-users and include outcomes of discussions held at various workshops and conferences. Some reports will be published in the International Water Association publication series, improving the visibility of European research. Examples are: 'Uncertainty Analysis' (Refsgaard *et al.* 2005), 'Model-supported implementation of the Water Framework Directive – A water manager's guide' (Hattermann & Kundzewicz 2007), 'Integration of the human dimension in model-supported water management' (Bots *et al.* 2007) and 'Good practice in joint use of monitoring and modelling' (Højberg *et al.* 2007b).

The WISE-RTD web portal. It is often a difficult task for practitioners dealing with new or challenging steps of the WFD, to find their way through the jungle of existing knowledge and experiences, when they look for assistance or good examples. *Harmoni-CA* has therefore developed a web portal (www.wise-rtd.info) that mainly acts as an entry to tools, experiences, guidances and research activities or results that can help water managers or others interested in finding information relevant to the WFD implementation.

Fig. 1. Map of Europe showing the locations of the six case studies discussed.

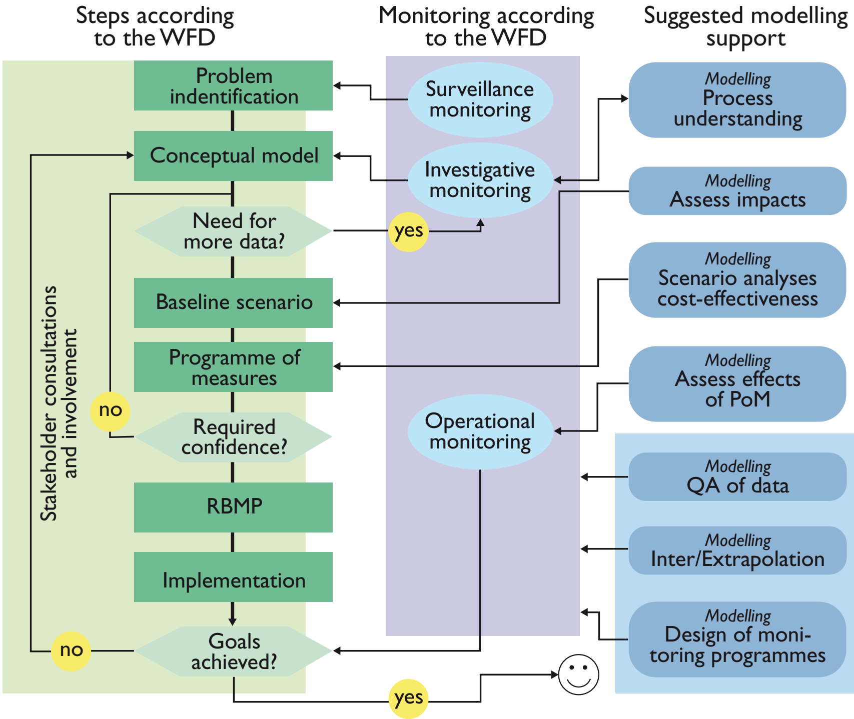
There are several ways to search for help in the portal. Users can enter in their capacity as water managers, scientists or stakeholders. Another option is to search by keywords derived from the 'Common Implementation Strategy Guidance Documents' developed by the EC to support the implementation of the WFD. Information on tests or pilot projects can also be found, such as the 'Pilot River Basins', where different steps of the WFD have been tested before final implementation. The portal is hosted and supported by the European Commission and is expected to become *the* support portal for WFD implementation.

Joint use of monitoring and modelling

While a combination of monitoring and modelling is often seen in research, there seems to be more hesitance to use modelling in practical water management where, on the other hand, a lot of data acquisition takes place. One of the tasks within *Harmoni-CA* was to try to integrate the monitoring and modelling disciplines in water management to a higher degree than currently seen.

For this purpose five workshops have been arranged over a period of three years. A total of more than 80 water managers, stakeholders, consultants, policy makers and scientists participated, representing 24 mainly European countries. The first three workshops investigated the status of monitoring programmes and the present use or knowledge of modelling support to monitoring. It was recognised that monitoring programmes often date back several decades and have traditionally been considered an independent discipline. However, within

Fig. 2. Flowchart for integrating monitoring and modelling activities when implementing the European Union's Water Framework Directive. The chart is a result of workshops on six case studies from different parts of Europe. The workshops addressed diverse challenges and problems of current interest. **RMBP**, River Basin Management Plans; **PoM**, Programme of Measures; **QA**, Quality Assurance.



the last few decades modelling has entered the arena as a supplementary tool to help extract information from observation data. This is generally accepted in the research community. However, in practical water management there is considerable reluctance to employ models due to various obstacles such as lack of skill, lack of time, lack of awareness on what models can do and also lack of confidence in models (Brugnach *et al.* 2007).

It was therefore decided to use the last two workshops to discuss six case studies from different areas of Europe (Fig. 1), in order to explore the possibility of developing an outline for a common approach in implementing the WFD and combining monitoring and modelling activities. These case studies are briefly presented here:

Hørup well field (Denmark). Groundwater extraction for drinking water results in low base flows in nearby streams in dry seasons. There are threats to the groundwater quality from diffuse pesticide pollution and from point sources (contaminated sites in a nearby city). The challenges in this case study were to ensure sustainable extraction without unacceptably affecting nearby streams and to protect the groundwater against pollution.

Ezousas aquifer (Cyprus). Heavy abstraction for irrigation causes saline intrusion into the aquifer. Groundwater recharge is low due to a decline in precipitation and damming of the river that previously supplied most of the recharge. The challenges were to convince stakeholders of the positive effects of a planned artificial recharge programme using cleaned wastewater, to optimise this programme to avoid saline intrusion and to evaluate the present monitoring programme.

Pärnu River Basin (Estonia). Threats to wetland and groundwater quality due to agricultural activities with both diffuse and point sources of pollution. Peat mining in the area leads to local acidification of surface waters. The challenges were to differentiate diffuse and point source contamination in surface water and groundwater and to address the acidification problem.

Nevesis River Basin (Lithuania). Surface waters are threatened by high nutrient loads from diffuse agricultural sources and from sewage from small villages without waste water treatment. The challenge was to differentiate between diffuse and point source contamination in surface water.

Campania (Italy). The groundwater, and thus the drinking water, is polluted by agriculture and horticulture, and outlets of untreated waste water from small villages contribute to poor groundwater quality. The challenge was to differentiate between diffuse and point source pollution.

Ialomita River Basin (Romania). High levels of nutrients, especially nitrate, in both surface and groundwater, caused by aerial deposition from neighbouring areas with agricultural activities as well as by diffuse pollution from the local agriculture. In addition, a special problem arises from high nitrate levels in the groundwater due to extensive use of nutrients in the past. The challenges were to differentiate between contamination caused by aerial deposition, local sources, and the inherited high nitrate concentrations from earlier agricultural activities.

Each case study was elaborated by a small group of participants, and flowcharts were prepared showing how to implement the WFD, with special reference to combining models and monitoring. The groups working on the six cases focussed on different aspects. In spite of this, their flowcharts showed many similarities in their approaches, which allowed the construction of a common flowchart representing the key aspects of all the six cases (Fig. 2). This flowchart may be applicable in most areas of Europe that face different challenges in the implementation of the WFD.

As shown in Fig. 2, models can support a variety of different tasks. A numerical model can be used to test different conceptual models and to check whether these are consistent with all available data. A model can be used to evaluate the effects of already implemented or planned measures, and by undertaking analyses of different scenarios help to choose the best programme of future measures to improve the status of the environment. Incorporation of data in models provides an additional check of the consistency and quality of the data, and since such data are often discrete in time and space, models are more applicable for interpolation and extrapolation than statistical methods. Models can also help to achieve an optimal design of monitoring programmes by providing input on when and how often to monitor. They can also help to find a predefined confidence level, taking uncertainty into consideration.

Thus models can support data acquisition in many ways, and this support may go much further than the traditional prediction of effects of various alternative initiatives.

Although the six case studies were real-life situations addressing topics of current interest, a major limitation was the fact that the participants did not have to consider political or economic constraints. Nevertheless, people with different backgrounds – scientists, practitioners, monitoring, modellers and experts – could easily work together in combining monitoring and modelling in an effective manner. All participants found the use of models to be beneficial in most of the situations mentioned above.

Concluding remarks

Different professional communities have different interests, traditions and working cultures. This constrains the uptake and acceptance of research results by practitioners and hinders the interaction of different disciplines such as monitoring and modelling. Experience from *Harmoni-CA* workshops on monitoring and modelling shows that when researchers and practitioners are brought together to elaborate on real life cases, they can easily work together in a very inspiring and constructive way. A key conclusion from the project is that it is possible to bridge some of the gaps between research and practice and between different disciplines, but that this requires continuous attention and positive co-operation from all parties involved.

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