ICT Requirements for an 'evolutionary' development of WFD compliant River Basin Management Plans

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Abstract: The Water Framework Directive (WFD) poses an immense challenge to integrated water management in Europe. Aiming at a “good ecological status” of all water resources in 2015, integrated river basin management plans need to be in place by 2009, and need to be broadly supported by stakeholders. Cost effective programmes of measures must be put in place to meet the objective of “good ecological status”. These measures reach beyond the direct water domain and touch on fields such as spatial planning, public participation and socio-economics. Much information and knowledge needs to be available to create these plans. Information & Communication Technology (ICT) tools, such as computational models, are potentially very helpful in designing river basin management plans (rbmp-s). Based on a vision on an evolutionary development of Decision Support Systems in a collaborative planning process, this paper elaborates some key requirements for modelling and ICT. The EU-funded cluster of projects “CatchMod”, including the concerted action “Harmoni-CA”, is discussed from the viewpoint of these requirements.

Keywords: Water Framework directive, ICT, modelling, collaborative planing

1. INTRODUCTION

In 2000 the European Parliament and Council passed the ambitious directive 2000/60/EC establishing a framework for Community action in the field of water policy, known as the Water Framework Directive (WFD). The key objective of this law is to achieve ‘good ecological status of Europe’s water resources by 2015.

A key aspect of the WFD is integration. The WFD aims at integrating amongst others: i) environmental objectives, combining quality, ecological and quantity objectives; ii) all water resources, combining fresh surface water and groundwater bodies, wetlands, coastal water resources at the river basin scale; iii) all water uses, functions and values into a common policy framework; iv) disciplines, analyses and expertise, combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics; v) stakeholders and the civil society in decision making, etc [1].

To achieve the WFD’s objectives a number of activities need to be carried out, leading to an Integrated River Basin Management Plan (RBMP) in 2009 (figure 1). Programmes of measures, leading to the desired state of the water resources need to be set. Measures may range from straightforward actions such as sewage treatment to financial incentives such as emission taxes for industry. The programme of measures should achieve the objectives in a cost-effective manner.

The WFD requires involvement of stakeholder, such as the environmental or agricultural interest groups, and the general public. Besides informing these stakeholders through consultation, active participation in developing objectives and programmes of measures is strived for. Reaching the overall objective thus will be a collaborative effort in which tailored information is of uttermost importance.

All this requires a huge effort in the design of River Basin Management Plans: effects of measures need to be evaluated in an integrated context, involving all the aspects mentioned above, and

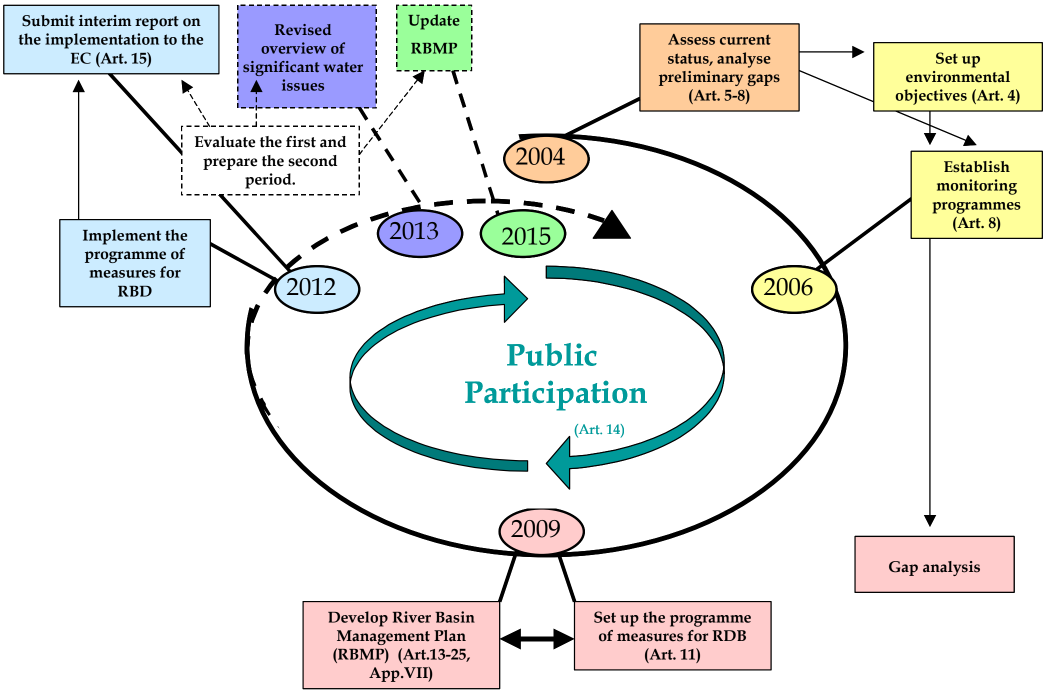

Figure 1: Visualisation of the time line of the WFD and its required activities and deliverables [1].

information needs to be accessible in the way that all different types of stakeholders achieve a common understanding of the problems, objectives and solutions.

This paper aims at identifying some major ICT and modelling issues from the perspective of collaborative planning and the limitations of integrated modelling systems. It builds on the author's view on an evolutionary development of Decision Support Systems during the WFD implementation. The paper provides global insight in research carried out in the EC supported catchment-modelling cluster (CatchMod).

2. THE WFD COLLABORATIVE PLANNING PROCESS

A simple schematisation of the collaborative planning process is presented in figure 2. In general, such a process consists of a closely interlinked 'planning process' path and an 'information delivering' path. The planning process part consists of 'start', 'problem definition', 'solution selection' and 'implementation'. Of course, this is a simplified representation: in a real-life situation the process is more continuous as new problems emerge, redefinition of problems is required and/or new solutions become available during the planning process (etc.). 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 collaborative process, 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, amongst whom the general public.

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.

3. DECISION SUPPORT TOOLS AND THEIR LIMITATIONS FOR THE WFD IMPLEMENTATION

In the past many tools have been developed to support water management. Especially in hydrology, computer modelling has been carried out for several decades. Integration of different domains in water modelling has lead to a broad availability of frequently large, advanced modelling suites. Specialists generally use such models and modelling suites.

In the last decade systems have been developed that integrate more and more domains, and can be used by non-specialist users. These developments often supported planning processes similar to the process described in the previous section. The systems emerged from linking existing models, expert rules, databases and other tools and developing the

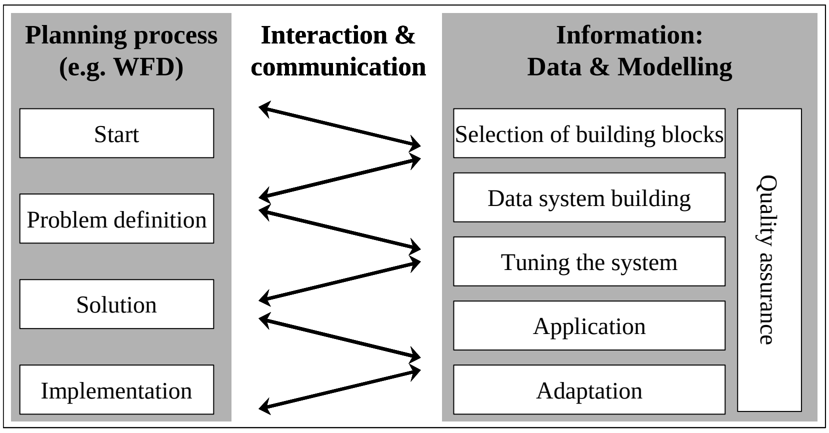

Figure 2: Simplified representation of the participatory planning process

means to calculate or visualize (pre-calculated) effects of different management options (measures). In such systems additions such as multi-criteria tools and cost effectiveness analysis tools provide means to achieve some optimisation during the selection of solutions. Though individual domain models also support decision-making the author reserves the word Decision Support System (DSS) for such integrated systems.

In the eyes of the author, the problem of the current DSS-s is that they have been developed for quite specific issues and do not cover the broadness of the WFD. The information path is often detached from the planning path, meaning that the information path is not closely following the demands from the planning path. Though the systems are of high quality, adapting them to new situations, e.g. changing and adding models, changing the geographic area they apply to, etc, is far from easy. It often requires much effort by both model & tool specialists and software developers. It is a major challenge for DSS developers (software developers and modelling specialists) to match the demands and the speed of the planning process.

The DSS development nevertheless has the distinct purpose of focussing discussion and gaining (mutual) understanding of all participants in a collaborative planning process. A DSS is therefore frequently called a Discussion Support System as opposed to Decision Support System.

A relatively new branch of software tools supporting the collaborative process are gaming and learning tools. These tools are extremely useful when aiming at common understanding between different stakeholders, each with their own backgrounds and interests. Gaming tools can be used to get common understanding of problems in river basins, but also to achieve understanding of (conflicting) interests, effects of behaviour patterns and decision making processes. They are thus very usefull in the early stages of a planning process. Gaming tools share similar problems as DSS-s – adapting them to new situations, issues and river basins is quite elaborate.

Today, we find ourselves facing the immense challenge to integrate more domains in water management, include all different types of stakeholders and develop cost effective programmes of measures as to meet the objectives of the Water Framework Directive. We need to find effective combinations of technical measures and socio-economic incentives to achieve good ecological status of Europe's water resources. Responsible River Basin Authorities all over Europe are working on the current requirements of the WFD, such as lists of protected areas, assessments of states and human impacts, setting preliminary objectives, etc. Soon, their focus of attention will move towards setting up monitoring programmes and programmes of measures.

4. MODELS AND TOOLS IN THE WFD AND ITS GUIDANCE DOCUMENTS

Models and tools are addressed at several points in both the legal WFD document and several guidance documents. It would be too far-reaching to provide a full overview within the scope of this paper, but for illustrative purposes some information is presented in this section.

In the legal document it states under section 1.3. Establishment of type-specific reference conditions for surface water body types it states '*Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods.*' In paragraph 1.5: Assessment of Impact it states: '*Member States shall use the information collected above, and any other relevant information including existing environmental monitoring data, to carry out an assessment of the likelihood that surface waters bod-*

ies within the river basin district will fail to meet the environmental quality objectives set for the bodies under Article 4. Member States may utilise modelling techniques to assist in such an assessment.' The guidance document on the planning process [1] explicitly states that it does not include '*Specific methodologies for the planning process: hydrologic modelling, decision support systems, etc*.' It does however acknowledge the usefulness of models: '*Although the systems approach to water resources planning is not restricted to mathematical modelling, models do exemplify the approach. They can represent in a fairly structured and ordered manner the important interdependencies and interactions among the various control structures and users of a water resources system. Models permit an evaluation of the economic and physical consequences of alternative engineering structures, of various operating and allocating policies, and of different assumptions regarding future flows, technology, costs, and social and legal requirements. Although this systems methodology cannot define the best objectives or assumptions, it can identify good decisions, given those objectives and assumptions.*' And '*Thus, the role models may be viewed as that of tools from which to derive answers to well-posed questions about the performance or behaviour of the system that is being planned. However, because of the dynamics of the planning process, it may happen that the answers derived from the models will suggest that the original questions were not well conceived and need to be reformulated. Hence, the role of models is iterative. They are used to produce information that may be fed forward to aid in decision-making (i.e., plan formulation). With equal value, they may produce information that is fed back to aid in redefining the problem*.'

The guidance 'Public Participation in relation to the Water Framework Directive' [2] and the guidance on impacts and pressures [3] provide numerous examples of the use of tools, mainly in its annex. The Guidance Document on Implementing the GIS Elements of the WFD [4] specifically deals with information systems and provides a data-model. It does not concern modeling and decision support systems.

Though the above does not provide a full analysis on ICT and modeling of the WFD and its guidances, it leads to the conclusion that only little guidance is provide on ICT and model requirements. This is supported by an analysis of WFD guidance documents on data aspects carried out by Blind and de Blois [5]. Though the WFD legal text and the guidances do not oblige the use of models and tools, the benefit of modeling and the use of tools is clearly recognized in the different guidances. What the factual role of models and tools will be during the WFD implementation is however yet unclear. This poses a problem for the development of Decision Support Systems.

5. THE AUTHOR'S VISION

In the author's view, it is necessary to integrate science, ICT technology, communication means in a very flexible, but scientifically sound manner to efficiently and effectively develop sound WFD compliant River Basin Management Plans. It is necessary to bring the DSS development much closer to the WFD planning process. In early stages of this process simple models and tools are required which allow the participants of a collaborative process to gain insight in the water system and achieve some common understanding and a basis for discussion. Based on the discussions on pressures, impacts, responses, measures [etc.] more detailed tools need to be incorporated. Since the time to develop the WFD compliant River Basin Management Plan is limited adding more detail to the DSS must be a simple and quick process. As the collaborative planning process progresses, the DSS will need to gradually evolve towards a dedicated DSS for the river basin at hand.

The key characteristic of this vision lies in the 'evolution' of the DSS. The author firmly believes that developing a single DSS from the beginning, either at a European, National or basin scale is not the way forward, since:

1) Such a system will need to incorporate all domains, problems and possible measures, for all different stages of the planning process, making it too large to develop from scratch, use it, and maintain it into the future. Differences in data-availability will add to this problem: a single system will need to work with low and high data-availability.
2) Each river basin has its own characteristics and problems, which requires local knowledge to be incorporated and dedicated development. The characteristics and problems are not limited to the natural sciences, but also include cultural, institutional and linguistic issues.
3) Scientific robustness, validity and transparency will be difficult, if not impossible to achieve.
4) Support from the research community will be lacking. On one hand because new insights will be difficult to incorporate, reducing the motivation of scientists to contribute, and on

the other hand because due to the fact that the selected tools and models will exclude alternative models and tools, practically excluding science and scientific debate from the DSS and widening the gap between research and practical application. The system becomes an 'institution' itself.

5) Creating a single system will (possibly) lead to exclusiveness, reducing competition, interfering markets and rendering past investments obsolete.
6) …

The main drawback of creating a single system is however that during the collaborative process unforseen questions will arise which cannot be supported. Subsequently, adaptations will be required. Adapting fully integrated systems is usually a complex endeavour given the complexity of the interrelations. The single system thus poses the great danger of being leading to the discussions in the collaborative process. In the collaborative process the planning process should lead the development of the information system.

The author believes that even on a river basin or national scale it will be very difficult to develop one system that answers all (yet unknown) questions.

6. ICT, MODEL AND TOOL NEEDS

As concluded in section 4 the WFD and its guidance documents do not provide direct guidance on particular tools and models, but do acknowledge the benefit of their use. Following from the vision of the author it is also clear that creating a single Decision Support System which supports the collaborative planning process and the development of river basin management plans is (in the author's view) not desirable, let alone feasible. The key ICT and modelling requirements should therefore lie on a more abstract or generic level, which supports the 'evolutionary' development of decision support systems. The key requirement to achieve this is a modular approach, in which models, databases and other tools are independent (small) units. Modularity alone, however, does not result in the flexibility and speed required for the collaborative process: the modules need a common interface, which allows information to pass from one model to another, to tools and user interfaces. Such an interface is required to allow quick linkages of modules to integrated systems, preferably without additional programming. The interface also allows swapping models, for example when more complex models are required. The standard should include the means to understand what data can be exchanged, either by providing a standard data-dictionary or self-descriptive methods (standard meta-data dictionary). Currently there is no broadly accepted interface and there are only few models and tools that share the same (IT) interface. Developing and agreeing on an interface standard is thus urgently needed.

If such a standard is developed and agreed upon models and tools need to be adapted to comply with this standard. The collection of models and tools should form a repository of modules, which can be flexibly linked. Besides obvious modules such as hydrological, ecological, economical (etc.) models, the repository must also include tools for multi criteria analysis, uncertainty analysis, gaming, etc. With respect to (non-specialist) end-users, exchanging information and data is not limited to passing numbers – the information must be useful to the recipients, thus information processing, filtering, translation of information need to be part of the repository as well.

In the author's view models and tools are readily available, and many alternatives exist in most scientific domains. Currently an extensive and comprehensive overview on available tools and models is lacking.

Structuring models and tools in a repository will allow gap analysis, and (cost) efficient further developments.

To further support the evolutionary approach to DSS development guidance is required to select 'the right tools for the right purpose at the right time'. This requires that for each model and tool sufficient meta-data is available to determine the usefulness. Of particular interest is the scientific soundness of a model or tool when linked with other tools. This requires scientific research resulting in practical guidances. Tool and model selection criteria should not be limited to 'content': the quality of the software should also be considered when integrating different models and tools.

Much of the time required to build dedicated decision support systems lies in the collection of data and populating the models. In modular, integrated systems using the same base datasets is often a problem. Though the three-tier approach (user interfaces, models and data-layer) is well known and agreed upon, many (legacy) tools require dedicated input. Improving this situation can be obtained through a standard interface as well. Furthermore a common (high-level multilingual meta-) data model is required. Given the anticipated complexity of WFD Decision Support Systems and need for flexibility much more effort is required to quickly link data and models. [Note: One should be aware that collecting the data for WFD reporting does not deliver a dataset that is sufficient for (advanced) modelling! Modelling will require much more detailed data.]

The foreseeable complexity of WFD related modelling and Decision Support Systems, the need for transparency of the collaborative process and the ambition to achieve some comparable quality in the (development of) River Basin Management Plans requires guidance and tools to develop, use, and record complex integrated systems. Such methods and tools should also support working in multidisciplinary teams and increase the trust in modelling results by, amongst others, the public.

Finally, one of the key requirements to achieve the vision of the author is improving the accessibility of models, tools and data. Legal and practical barriers prohibiting quick and easy use of tools need to be resolved, e.g. by harmonized access rights and technologies such as web services. This does not mean that software should be free of charge.

The above points form the basis need for an evolutionary approach to WFD Decision Support System development. Other tools related challenges are also very important and require attention:

- The scientific linkage between freshwater and coast and sea.
- Integrated uncertainty assessment (data models, planning process)
- Multilingual support and support tools in transboundary regions
- Integration of earth observation technology
- …

In the view of the author, the issues raised above are very important for developing the River Basin Management Plans, but it is certainly not a complete list of issues.

7. THE CATCHMOD INITIATIVE

The European Commission's Research Directorate General supports a number of research projects and a concerted action that focus on supporting the WFD implementation using computational models and other computational tools. These projects are clustered in CatchMod, the catchment-modelling cluster (figure 3, table 1). In the previous sections the vision of the author and subsequent requirements have been elaborated. In this section the CatchMod projects are introduced in the light of the requirements.

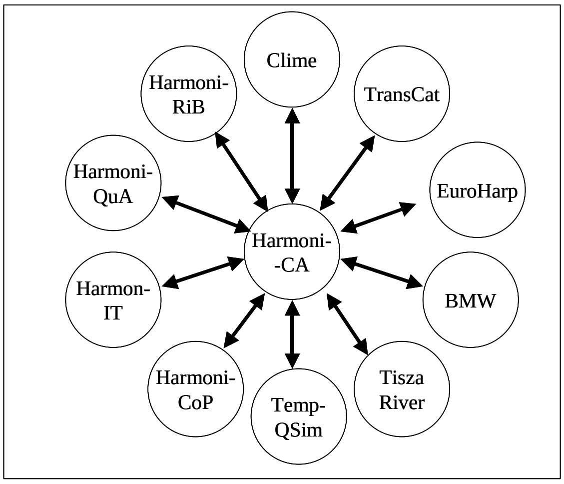

Figure 3: The CatchMod projects (acronyms).

The HarmonIT project is developing a standard interface for data-exchange. On a meta-level it defines structures for data description. The BMW project develops benchmark criteria for models, facilitating the proper selection. Euroharp compares a suite of models for nutrient emissions, which is also helpful for model selection. Many other projects will research the applicability of models in different situations; for example, in TempQSim the specific requirements for water quality models in temporary waters are researched, including the aspects of data availability. In Clime, the linkage between climate change and ecology is under investigation. Databases including uncertainty information and being able to hold many different types of data from all WFD relevant domains, and methodologies for uncertainty propagation in integrated modelling are researched in HarmoniRiB. HarmoniQuA elaborates guidance on the proper setting up and use of integrated modelling systems. It develops tools, which help the modellers, both by providing advice and structure, as in providing reporting structures and communication facilities to non-modellers. In the HarmoniCoP project the use of tools for collaborative planning, including gaming and DSS are researched, leading to guidance on collaborative planning including these aspects. Transboundary modelling, data issues, multilingual problems and transboundary communications are key points of attention in the TransCat and Tisza River projects.
So all the above projects are in part of the same cluster, their time-lines limit the possibilities to re-use each other's results 'on the fly'. The concerted action Harmoni-CA's task is to facilitate the synthesis, for example by supporting the benchmarking of all models using the BMW criteria. Harmoni-CA should further facilitate and synthesize

HarmonIT	IT Frameworks (2002-2005) Hwww.harmonit.comH
BMW	Benchmark Models for the Water Framework Directive (2002-2004) Hhttp://www.ymparisto.fi/default.asp?node=11687&lan=enH
EUROHARP	Towards Harmonised Procedures for Quantification of Catchment Scale Nutrient Losses from European Catchments (2002-2005) Hwww.euroharp.orgH
CLIME	Climate and lake impacts in Europe (2003-2005) Hhttp://www.water.hut.fi/climeH
TempQSim	Evaluation and improvement of water quality models for application to temporary waters in southern European catchments (2002-2005) Hwww.tempqsim.netH
TISZA RIVER	Real-life scale integrated catchment models for supporting water- and environmental management decisions (2002-2004) Hwww.tiszariver.comH
HarmoniCoP	Harmonizing Collaborative Planning (2002 -2005) Hwww.harmonicop.infoH
TRANSCAT	Integrated water management of transboundary catchments (2003-2006) Hhttp://transcat.isq.pt/H
HarmoniQuA	Harmonising Quality Assurance in model based catchment and river basin management (2002-2005) Hwww.harmoniqua.orgH
HarmoniRiB	Harmonised techniques and representative river basin data for assessment and use of uncertainty information in integrated water management (2002-2006) Hwww.harmoniRIB.comH
Harmoni-CA	Concerted action on Harmonised Modelling Tools for Integrated Basin Management Hwww.harmoni-ca.infoH

Table 1: The CatchMod projects

discussions on the use of models and tools in general, the science-policy interface, the modelling-monitoring relationship and develop a broadly supported overall methodology, in which all methodologies developed by the scientific community get a clear place. Harmoni-CA also works on improving the accessibility of models and data. A communication services centre is set up to facilitate to improve the linkage between the WFD demand side and the supporting side of science and technology. It speaks for itself that all CatchMod projects have many more objectives than described above. All projects apply a range of models in rea-life-cases and discuss with end-user groups.

8. SUMMARY & CONCLUSIONS

The difficulty in making the ICT demands of the WFD tangible lies in the fact that the WFD legal text and guidance documents do not provide guidance on the use and requirements of models and tools. As a result a list of tools and tool characteristics cannot simply be elicited from these documents. It should be clear that it is not the intention of the WFD to be a straightjacket, and there is common agreement that the implementation is requires tailored approaches.

Discussions at the Harmoni-CA conference [6] between people involved in the implementation process (WFD managers) and scientists / modellers did not result in a clear-cut view on ICT / modelling requirements.

Instead of waiting for requests, it is the author's view to anticipate the potential need for modelling and Decision Support Systems in the WFD phase 'development of River Basin Management Plans'. The modelling and ICT world needs to be ready to deliver quickly, as soon as the questions are emerging from the planning process. The author advocates some key requirements which together form an 'infrastructure': a set of basic standards and guidances which support an 'evolutionary' approach of DSS development. The reasoning originates from the assumption that modelling and information will be an important aspect in implementing the WFD. However, different views on the necessity and use of advanced tools exist, and only time will show how much use will be made of models and ICT.

Obviously, a gap remains between the 'infrastructure' requirements advocated by the author, and practical DSS systems required for implementing the WFD. This gap will be closed as tangible requirements for support emerge. If the key requirements are met, the integrated modelling community can quickly deliver

The CatchMod Cluster of projects delivers potential solutions to many of the issues addressed. The results of the projects will require harmonisation and future support. It is the task of Harmoni-CA to facilitate both aspects of CatchMod.

CatchMod is 'just a cluster' of modelling and ICT related projects and represents just a fraction of research going on in this particular field. In other EC-research and in national projects ICT issues such as distributed databases, distributed modelling, metadata standards and web-based applications are developed. Of course, also issues addressed by CatchMod projects are addressed in other projects. Synthesizing available knowledge must include these initiatives – Harmoni-CA should facilitate this process.

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