1. INTRODUCTION

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1.1 Background – the HarmoniQuA project

During the last decade a growing interest could be noticed in problems related to model based decision support in general (Scholten & Udink ten Cate, 1996) and also specifically in water management. These problems are manifold and include, but are not restricted to technical problems associated with modelling and simulation software, data handling, measuring errors and other uncertainty in system observations, selection of an appropriate model, lack of data, error propagation in coupled models, the increased technological power to calibrate complex models, soft, procedural items associated with stakeholder participation, and translating model results to the level of understanding of managers and decision makers.

Since computers became available for calculations in water management, models are used to support decision-making. From these early days on, a palette of methods have been developed to enable and support modelling and simulation in all domains of science. These methodological developments were separated and independent of each other up to a large extent. In water management separate pathways were followed in modelling methods within the different domains, i.e. hydrology, ground water, water quality etc. The last ten years it became obvious that experts in these fields could not easily co-operate within modelling projects covering and integrating several of these domains, because of different, incompatible methods. Modellers from different disciplines could not automatically understand each other.

A second more immediate cause to assess modelling problems in water management is given by the Water Framework Directive (WFD) and its implementation. The WFD provides a European policy basis at the river basin scale. The river basin management and planning process prescribed in the WFD focuses on integrated management, involving the availability of both surface water and groundwater resources as well as the demands from the different (often competing) sectors such as water supply, agriculture, industry and the need of water to preserve our aquatic ecosystems. The WFD emphasises an integration of socio-economic aspects into the planning process. In the WFD it is explicitly mentioned that water resources models should be used to support the planning process and the decisions.

The WFD challenges water managers to cope with a complex of problems. Increased problem scale and an integrated approach force organisations to co-operate. This raises the need to couple models and to incorporate socio-economic aspects. Sound coupling of models requires a widely accepted, transparent methodology.

There is a growing interest in quality aspects in modelling and simulation for water management. In the past few years, several initiatives within and outside Europe have been launched to improve the credibility of model based decision support in general. Both from a scientific and public side, a gap is perceived between the required and available functionality of models in water management. Due to this discrepancy, confidence in the use of models is decreasing, whereas at the same time the water managers increasingly base their decisions on these models.

The Dutch initiative to asses quality assurance for model based decision support in water management by means of a Good Modelling Practice Handbook (Van Waveren et al., 1999, Scholten et al., 2000, 2001) was one of the reasons to discuss a series of ideas for a European scaling up of plans to support WFD implementation. Several meetings in Schiphol /Amsterdam Airport and Brussels with key-players in the field of model based water management have been used to check the interest in such an initiative. As a result plans for five projects were presented in Madrid at the EurAqua meeting, October 2000. A large part of the representatives of the EurAqua countries were interested and agreed upon making proposals for financial support within the EC Energy, Environment and Sustainable Development programme of FP5.

Within three months these ideas were transformed to a series of proposals and send to Brussels for evaluation. Several months later the quality assurance proposal, called HarmoniQuA (Harmonising Quality Assurance in model based catchment and river basin management) was one of the proposals that was selected for financing. Several months of negotiations ended in signing contracts for a project of M€ 2.55 of which M€ 1.65 is financed by the EC. The project runs from January 2002 until December 2005. Partners in HarmoniQuA are spread all over Europe, covering all required expertise and working in different economic, environmental, social and climate conditions (Figure 1.1):

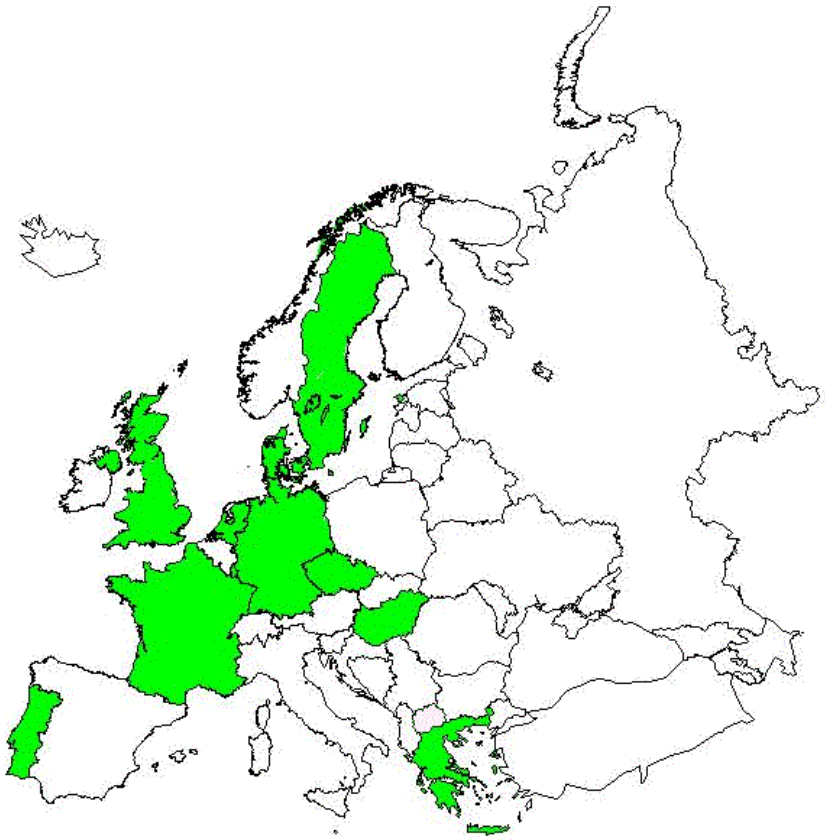

Figure 1.1 Countries with HarmoniQuA partners

1. Wageningen University , Information Technology Group (*WU*), Wageningen, The Netherlands, co-ordinator and WP-2 leader
2. Geological Survey of Denmark and Greenland (*GEUS*), Copenhagen, Denmark, WP-1 leader

3. National Technical University of Athens (*NTUA*), Athens, Greece, WP-3 leader
4. Centre for Ecology & Hydrology (*CEH*), Wallingford, UK, WP-4 leader
5. WL | Delft Hydraulics (*WL | DH*), Delft, The Netherlands
6. *Cemagref*, Antony, France
7. Bündesanstalt für Gewässerkunde (*BfG*), Berlin, Germany
8. Swedish Meteorological and Hydrological Institute (*SMHI*), Norrköping, Sweden
9. *VITUKI* Plc , Budapest, Hungary
10. University of Dortmund , Institute of Environmental Research (*INFU*), Dortmund, Germany
11. Laboratório Nacional de Engenharia Civil (*LNEC*), Lisboa, Portugal
12. DHI Hydroinform a.s. (*DHI*), Prague, Czech Republic

HarmoniQuA aims to be a component of a future infrastructure for model based water management at catchment and river basin scale. This main goal will be reached by providing the following elements of a methodological layer in this infrastructure. HarmoniQuA will upgrade methodological expertise and identify and fill gaps in it. This knowledge on modelling and simulation will consist of generic and domain specific knowledge, and further of software specific aspects and a transparent and consistent glossary of terms and concepts.

This body of knowledge will be structured in a knowledge base in order to facilitate using and upgrading it. A software tool will be developed which will produce guidelines to help modellers, managers and auditors throughout a model based water management study. These guidelines will further be specific for the type of application (planning, design, operational management) and specific for the complexity of the task (basic, intermediate, comprehensive). A next tool will monitor all tasks performed in such studies and will store these model project summaries in a database. These monitored summaries will use a similar data structure as the knowledge base. Another tool will enable domain, user, application and job type specific reporting of all tasks and activities performed in a study. Finally a tool will use these monitored modelling histories to learn from the past in future projects.

The HarmoniQuA products (knowledge base and tools) will be tested in two series of professional case studies covering multi-domain (≥ 2 domains) and integrated (≥ 2 domains, but socio-economic aspects included) model based water management studies throughout Europe.

Finally, a dissemination and exploitation infrastructure will provide long term support and guarantee future use by the entire community of modellers. This will be achieved by setting up an infrastructure for dissemination and exploitation for project benefits, designing, preparing and providing courseware to train new professionals in good modelling practices; organising workshops and discussion sessions with professional bodies and practitioners to facilitate moving towards harmonisation and standardisation for modelling in water management at a European level; opening up the concept of quality-controlled modelling to any interested stakeholders including planners, policy-makers and concerned members of the public.

Further information can be found on www.harmoniqua.org

1.2 **Purpose and content of the present report**

1.2.1 Objective and limitations

The objective of the present report is to provide a state-of-the-art of methodologies and guidelines related to quality assurance in water resources modelling. This includes methodologies prepared for international scientific purposes as well as national guidelines prepared for management purposes. The conclusions from the present report

will form the basis for the further HarmoniQuA work on establishment of a common glossary and a generic set of guidelines and methodologies.

The HarmoniQuA guidelines to be developed shall be generic in the sense that they cover all domains required for the Water Framework Directive and at the same time be applicable across Europe where a significant range of practices presently exist. HarmoniQuA aims at extracting the best of the existing guidelines and practises. Therefore, the reviews provided in the different chapter of the present state-of-the-art report aim to cover the diversity both across the different disciplines of modelling and between different countries in Europe.

The reviews aim at covering the disciplines, or domains, of modelling that will be required for implementing the Water Framework Directive. These domains cover the topics of surface water, groundwater, water quality, ecology and socio-economy for inland water, transition waters and estuaries. In HarmoniQuA they are subdivided into the following seven domains:

- Groundwater modelling
- Precipitation-runoff modelling
- Hydrodynamic modelling (including sediment and morphology models)
- Flood forecasting modelling
- Surface water quality modelling
- Biota (ecological) modelling
- Socio-economic modelling

A limitation of the definition of the topics in these domains is that storm surge modelling, i.e. forecasting of coastal floods due to storm surges in the sea, is not included. The reason for this is that, although coastal floods occur at the cost line and as such in the geographical area covered by the Water Framework Directive, these floods originate from the ocean and therefore the models dealing with these types of floods are fundamentally different from models dealing with river generated floods.

1.2.2 Content – a reader's guide

A summary of the different practices of using quality assurance guidelines for modelling that can be found among the different domains and between countries is given in *Chapter 2*. This chapter also contains our recommendations on which key elements from the various existing guidelines and which new elements should be emphasised or added in the further HarmoniQuA work on establishment of generic guidelines.

Quality assurance in modelling involves establishment of a common terminological foundation. In addition, it inevitably touches upon fundamental and controversial issues such as whether a model can be said to be verified or validated at all. This is addressed in *Chapter 3*, where a theoretical framework is proposed, including a consistent terminology and the foundation for a methodology bridging the gap between scientific philosophy and pragmatic engineering. With its focus on scientific philosophical issues and terminology, Chapter 3 may appear to be somewhat 'heavy' to read. It should be emphasised in this regard that the other chapters can easily be read independently of Chapter 3. Chapter 3 forms the basis for establishment of a common glossary that is a future HarmoniQuA deliverable.

State-of-the-art on methodologies and guidelines for quality assurance in the different disciplines of modelling are described by separate reviews for the seven domains listed above (*Chapters 4-10*).

The present report does not focus on the modelling techniques or model codes as such. Thus, there is no thorough description of various modelling techniques or reviews of modelling codes. As quality assurance in the modelling process requires supporting software tools a review has been made of the capability of existing model software packages in this respect (*Chapter 11*). The aim of this review is to analyse whether the new guidelines and methodologies to be developed in the HarmoniQuA to a reasonable

degree can be supported by existing software packages or whether a fundamental gap exist.

The diversity in practises between countries is illustrated through a number of case studies presented in *Chapters 12-19*. Reflections of the reasons for these differences are made in Chapter 2.

By reading the report it is easily noted that different terminology is used in the different chapters. The terms used in the different chapters reflect the actual terminology used in the respective modelling domain or country. These significant differences in terminology clearly by themselves illustrate the need for establishing a common terminology, but on the other hand also indicate that the terminology proposed in Chapter 3 and the coming HarmoniQuA glossary may not be easily accepted by all corners of the modelling community in Europe.

1.3 Acknowledgement

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1.4 References

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