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Sgobbi A., Giupponi C.

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MODELS AND DECISION SUPPORT SYSTEMS FOR PARTICIPATORY DECISION MAKING IN INTEGRATED WATER RESOURCE MANAGEMENT

A. Sgobbi*[,] and C. Giupponi**[,***]**
*Università Ca Foscari, School for Advanced Studies in Venice Foundation, Venice International University, Island of San Servolo, Venice 30100, Italy
**Fondazione Eni Enrico Mattei, Campo S. Maria Formosa, Castello 5252, 30122 Venice, Italy
[***]Università Statale di Milano, Dipartimento di Produzione Vegetale, Via Celoria, 2 I-20133 Milano Italia.

SUMMARY - The requirement for public participation is implied by integrated water resource management and enshrined in many international, regional and national legislations. Its implementation is however problematic: although models and decision support systems could provide useful support, their uptake is very limited in practice. The objective of this paper is to analyse the role of models and identify future research directions in support of integrated water resources management (IWRM). The role of participatory modelling is explored through the experience gained with several European research projects, sharing the common aims of contributiong towards improved decision processes and tools (i.e. decision support systems, DSS). The main sector interested by these experiences is agriculture and the geographical area is the Mediterranean Basin.
The process of participatory modelling and related software tools developed since the beginning of the years 2000 with the EU project Mulino and further developed within the NetSyMoD approach, has shown positive impacts in the case studies in which it was tested. New methods and tools such as those developed at FEEM-NRM can effectively support, and be functionally integrated with the planning and management processes prescribed by the EU Water Framework Directive and more broadly with the principles of IWRM. Participatory modelling could offer support for integrated water resources planning and managing. Some open questions, however, remain, which require further consideration, such as: (i) triggers for the process of model and DSS implementation by potential end users; (ii) training requirements of potential end-users; (iii) model usability and re-usability; (iv) problem complexity and new technologies vs. the need for simplification of tools and approaches to be implemented in the real world. Finally, there remains a strong need for scientific and technical support for the meaningful involvement of stakeholders in planning and implementation through participatory modelling.

Key words: water resources management, modelling, decision support, public participation.

RESUME *- Le besoin d'assurer la participation publique est implicite à la notion de gestion intégrée de ressources en eau et fait partie intégrante de plusieurs législations internationales, régionales et nationales. Son implémentation est toutefois problématique: même si les modèles et les systèmes de support à la décision peuvent offrir un aide efficace, leur application est limitée. L'objectif de cet article est d'analyser le rôle des modèles et d'identifier des orientations futures de recherche en support à la Gestion Intégrée des Ressources en Eau (GIRE). Le rôle de la modélisation participative a été analysé à travers l'expérience acquise durant plusieurs projets de recherche européens, partageant le but commun d'améliorer le processus de prise de décisions ainsi que les outils (i.e. Systèmes d'Aide à la Décision, SAD). Le principal secteur intéressé par ces expériences est l'agriculture ; la zone géographique est le bassin méditerranéen.*
Le processus de modélisation participative ainsi que les logiciels y afférents développés des le début des années 2000 par le projet européen Mulino et, en suite, via l'approche NetSyMoD, se sont traduit par des résultas positifs pour les cas d'étude concernés. Des nouvelles méthodes et instruments, tels que ceux développés par le group de recherche FEEM-NRM, sont en mesure de fournir un support efficace et peuvent être fonctionnellement intégrés au cours des processus de planification et gestion prescrits par la Directive Cadre sur l'Eau (EU) et plus amplement par les principes de la GIRE. La modélisation participative pourrait offrir un support à la planification et à la gestion des ressources en eau. Quelques questions ouvertes, toutefois, demeurent et nécessitent des considérations plus approfondies, telles que : (i) le déclanchement du processus de modélisation et de l'implémentation de SAD par les usagers finaux potentiels ; (ii) les besoins concernant l'apprentissage des usagers ;

(iii) accessibilité dans l'utilisation et la réutilisation ; (iv) la complexité du problème et des nouvelles technologies vs. le besoin de simplifier les outils et les différentes approches pour leurs applications dans le monde réel. En fin de compte, il reste un besoin important de fournir un support technique et scientifique vers une implication efficace des porteurs d'intérêt dans la planification et implémentation à travers la modélisation participative.

Mots-cléfs: *gestion des ressources en eau, modélisation, aide à la décision, participation publique.*

INTRODUCTION

According to the definition provided by the Global Water Partnership (GWP), Integrated Water Resources Management (IWRM) "is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP-TAC, 2000). A common paradigm within the context of IWRM is the relevance of the participatory approach, which is becoming a prerequisite of every legislation and plan. According to the GWP again, Public Participation (PP) requires "that stakeholders at all levels of the social structure have an impact on decisions at different levels of water management". Only PP at all levels (international, national regional and local) may assure transparency and accountability of the policy/decision process. In the field of water management, integrated approaches to the resource imply the need for considering the social aspects of water use, as well as the economic and environmental spheres.

In parallel to the ever increasing emphasis on PP, there is an increasing attention to the role that could be played by information and communication technologies (ICT) in the IWRM process. Within the broadest category of ICT tools, a particular attention is given in this context to simulation models and Decision Support Systems (DSSs). It is out of the purposes of the present work to go deeply in the discussion of neither modelling nor decision making theories, nevertheless, it is important to point out that the first category of tools, provide the only scientifically based approach to introduce projections and predictions, which are prerequisites for any planning activity, including IWRM. DSS tools are, on the other hand, those tools that are specifically designed to support decision/policy making processes and therefore, given the extreme intrinsic complexity of the IWRM, present an evident strong positive potential.

By combining the need for advanced ICT tools (dealing with both scientific evidences and subjective knowledge) and robust participatory approaches (allowing to extend the group of people involved in the decision making process outside a small number of experts – including modellers – and decision makers), *participatory modelling* emerges as a possible solution to problems common to both modelling and PP.

By the term "participatory modelling" we designate a process in which the formulation of a conceptual model and its formalisation is carried out by disciplinary experts with the direct involvement of stakeholders. Various techniques are available in this field, such as creative system thinking and brainstorming, cognitive mapping, causal loop diagrams, etc. The participatory formalisation of the underlying model (i.e. the socio-ecosystem affected by the problem in question) allows for the identification of the main components of the system and their linkages, typically by adopting system analysis formalisation in form of stock (state variables), flows (of energy, matter, information) and casual links (e.g. feedback loops).

Participatory modelling provides a common basis of shared knowledge upon which discussions and deliberation about the issue in question can later on be established, provided that the technique adopted to elicit actors' views, and the ability of the facilitator to limit the risks and shortcomings of participatory processes, are sufficient.

Despite the theoretical potential, experience has shown that the uptake of modelling approaches and computer tools to support decision and policy making is very limited in practice (see, for instance, Zapatero, 1996). Traditional modelling techniques have limited impacts on policy making, especially with respect to complex systems such as those involved in natural resource management: these problems – often referred to as “wicked” (Rittel and Webber, 1973) “messy” (Ackoff, 1979) and “hazy” – are difficult to structure, as their understanding depends on the analysis’ perspectives. In these cases, the integration of policy actors in the model building process is deemed useful (Geurts and Joldersma, 2001).

Many research efforts have recently began exploring means and ways to tap into the yet unrealised support that models and the modelling process could offer to participatory river basin planning for IWRM. It is within this context that this paper originates, with the aim of building on recent research experiences[1] to offer insights into future research needs in support of participatory planning for integrated water management. More specifically, the purpose of this paper is to illustrate how models, in the broad meaning of the term, could support the integration of political and social dimensions in IWRM.

The remainder of the paper is organised as follows. In order to put the present research into context, the next section goes deeply in the analysis of the role of PP in natural resources management, while the following section explores the use of the terms “model” and “DSS” within the IWRM paradigm. The forth section discusses the specific experience of the MULINO Project for the implementation of the concepts of IWRM, with specific reference to the EU Water Framework Directive and its implementation process, drawing some general lessons for what concerns public participation. The last section presents some concluding remarks and insights for future research agenda for improving the effectiveness of participatory modelling, with focus on the problems typical of the Mediterranean Region.

PUBLIC PARTICIPATION AND NATURAL RESOURCES PLANNING AND MANAGEMENT

Public Participation is intended as a process to improve decision-making, by ensuring that (i) decisions are soundly based on shared knowledge, experiences and scientific evidence, (ii) decisions are influenced by the views and experience of those affected by them, (iii) innovative and creative options are considered, and (iv) the new arrangements are workable, and acceptable to the public. Participatory decision-making is thus expected to lead to better decisions and strategies, as well as to reduce conflicts and facilitate enforcement. Several authors have recently suggested that participation in decision making is an expression of “normative consideration for the democratic principle” (Stirling, 2006), that is, a “combination of deliberation and equitable involvement of parties” (Renn, 2006) as opposed to the traditional view of representative democracy and command and control management.

The concept of public participation as an important prerequisite for achieving sustainable development clearly emerged in international discussions as early as 1992, during the Rio conference. In particular, Chapter 8 of Agenda 21 (UN, 1998a) is devoted to public participation, and identifies “information”, “integration” and “participation” as key factors for helping countries to achieve a sustainable development.

In the same year, the “Dublin Statement on Water and Sustainable Development”[2] was adopted at the International Conference on Water and the Environment, stressing the importance of a holistic, comprehensive, multi-disciplinary approach to water resources. Participants to the Conference called for Integrated Water Resource Management (IWRM), based on four guiding principles covering economic, social, environmental and political issues. Principle 2 of the Dublin Statement states that “water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels” (ICWE, 1992). Within the context of IWRM, public participation implies that the general public is informed about the importance of water and its management, and that decisions are taken at the lowest possible level, with public consultations and the participation of users.

Since 1992, the concept of PP has been integrated in a variety of international treaties and conventions: the Helsinki Convention (UN, 1992) requires at a minimum information disclosure to the

[1] The focus is in particular on the analysis of the experiences gained at FEEM-NRM (Fondazione Eni Enrico Mattei, Natural Resources Management Research Programme) within recent EC funded projects and, in particular, the MULINO Project “Multi-sectoral Integrated and Operational Decisional Support System for Sustainable Use of Water Resources at the Catchment Scale” (Giupponi, 2006).
The full text can be found at: http://www.wmo.ch/web/homs/documents/english/icwedece.html

public. The Aarhus Convention (UN, 1998b) further formalises the requirements of pubic participation. At the European level, the EU Water Framework Directive (WFD) specifically calls for participation in river basin planning and management, recognising the potential benefits of this approach in terms of: (i) increased awareness of environmental issues; (ii) facilitation of integrating the knowledge, experience and initiatives of different stakeholders in the decision process, thus improving it; (iii) increased probability of public acceptance, commitment and support; (iv) a more transparent and creative decision making; (v) and, finally, the reduced likelihood of confrontations, conflicts, and litigations arising from the decisions and/or its implementation (EC, 2003a).

There is now an extensive literature on the importance of public participation in decision making, especially for environmental matters in relation to sustainable development – see, for instance, Pimbert (2004). In recent years, however, fundamental criticisms to the role of, and means to, public participation are being voiced by both practitioners and researchers. Politicians may have strategic incentives to hamper public participation, as they may not be willing or ready to relinquish part of their decision making power, or they may fear loosing control over the decisional processes. Public participation itself may become an instrument for control. Without an appropriate and consolidated implementation framework, PP can indeed have unintended negative consequences, such as political co-option, or the legitimisation of decisions favoured by the majority of those involved (Mosse, 1994; Nelson and Wright, 1995; and Cooke and Kothar, 2001). Not enough attention has been devoted to the adequate integration of power relations between elite groups and the less powerful (see, e.g., Hildyard *et al.*, 2001 and Taylor, 2001, as well as Hailey, 2001 and Stirling, 2006), with the real (and documented) risk of public participation used as “a means for top-down planning to be imposed from the bottom-up” (Hildyard *et al.*, 2001, p. 60). Furthermore, who should take part in the process is not clearly defined, nor are there agreed upon mechanisms for the correct identification of the stakeholders to be involved in the process – individuals or groups (Swyngedouw *et al.*, 2002).

Despite its critiques, there is a widespread emphasis on deliberative decision-making remains, including at the national and international legislative levels. Deliberative democracy supporters argue that legitimate lawmaking can only arise from the public deliberation of the citizens: this increasing emphasis on the participatory paradigm is leading to a proliferation of techniques and practices for PP, which may provide significant improvements in the management of natural resources in general, and for IWRM in particular. Yet, although PP is both a right and a practical necessity, its forms, mechanisms and functions need to be carefully shaped (Dalal-Clayton and Bass, 2002).

Approaches derived from the disciplines of system analysis and modelling can help in the systematisation and structuring of stakeholders and experts knowledge, offering methodological and techno-scientific solutions to the increasing need for scientifically sound methodologies. These should guarantee the objective and transparent integration of stakeholders’ preferences and inputs in the final decision, through structured approaches, which can be successfully applied under a variety of conditions.

SETTING THE PROBLEM INTO CONTEXT: MODELS, DSS AND IWRM

Before entering into the discussion of participatory modelling as a means towards the full implementation of IWRM, an explanation of how models and DSSs are interpreted in this paper is needed. In fact, policy makers and researchers often have a different understanding of the word “model”, as well as different expectations over what a model can(not) do.

Traditionally, modelling in IWRM is seen as an applied method for integrating the various components of a river basin system and their interactions from a wide range of disciplinary perspectives, such as hydrological, economic, agronomic and ecological (Letcher and Bromley, 2005). There is therefore an implicit reference to a mathematical formalisation of reality which, in the context of river basin management planning, relates models mostly to physical and ecological processes, such as nutrient balance, sediment transportation, and hydrological models. The social dimension is often not included, as it is difficult to formalise. In this literal sense of the term, “physical” models could be understood as computer tools, in which systems of differential equations are used mainly for research purposes, or for management issues and, sometimes, for forecasting or exploring different future scenarios in the field of hydraulics, hydrology, geomorphology, water ecology and chemistry; such tools traditionally lack the integration of socio-economic aspects (Hare, 2004b).

Designed to answer specific questions in specific settings (e.g. resource allocation, water quality, etc.), such models cannot be easily reapplied in different contexts (McIntosh *et al.*, 2004).

In recent times the role of modelling in the application of IWRM and the definition of “models” has become more encompassing, intended “broadly, to consider both what they represent in the river basin (e.g. run-off, population change, stakeholder perceptions) and how they may be packaged for use” (Hare, 2004b, pp. 43-44). Despite this broader meaning, a bias is still often present, and models are equated with tools, without due consideration to the processes involved in model conceptualisation, development and use.

This narrow definition of models as tools has generated some confusion when exploring participation and modelling. Many experts and practitioners alike understand the word in a broader sense, not limited to physical, mathematical representations of reality, but encompassing mental models and the related cognitive maps as well – thus the social dimension of water management. Mental models refer to an “internal”, subjective representation of reality, while mental maps are to be understood in this context as the processes and techniques used for “external” representations of mental models (Doyle and Ford, 1998) – that is, as means to share the subjective view of reality. External representations of mental maps can then be transferred to a wide range of computer tools – either in a formal, mathematical format, providing insights or forecasts in physical processes, as a way of representing and organising knowledge about the (management) system, or of supporting communication and decision making, and, therefore, PP. The term “external” is often omitted, yet it plays a fundamental role for the purposes of the present paper. In fact, a crucial assumption for effective participatory modelling is that any manifestation of “external” models or modelling activity may exist as representation of (internal) mental models. Cognitive mapping techniques play a key role in ensuring that the emerging external model(s) is a fair enough representation of internal structures and beliefs, as well as a good enough compromise view of the problem under discussion. Vennix et al (1990) offer an extensive review of literature on cognitive mapping, and guidelines on how to structure the knowledge elicitation process. Other methods for problem structuring are discussed in Mingers and Rosenhead (2004), Rosenhead (1989), Rosenhead and Mingers (2001), Flood and Jackson (1991), and Dyson and O'Brien (1998).

Where modelling is applied in decision making and planning processes, a specific category of broadly indented models come into play: DSSs. Decision Support Systems are commonly defined as tools to support the structuring of a decision making problem, as well as improving the effectiveness and acceptance of the final policy choice. Referring specifically to natural resource management applications, DSSs can support the organisation of information and knowledge in such a way that policy makers are able to analyse and compare different management strategies, and to integrate their own priorities and value judgments in the decision making process in a transparent way (Mysiak, 2005).

Only by accepting the challenge of approaching the internal component(s) of models in a participatory context to construct their external counterparts, can we expect to harness the full potentials of modelling for improved resource management. Unfortunately, this has rarely been the case in the recent history of PP. To complicate matters further, the potential role of modelling itself has been questioned in recent times, with decision makers often viewing models (including DSS) as “black boxes” which cannot be fully trusted. The debate about climate change has remarkably contributed to the crisis of credibility of models (van der Sluijs, 2002). There is in fact a general perception that modelling, and in particular scenario models for future projections, remains an academic exercise with very strong components of subjectivity and uncertainties. As such, the results of models cannot be fully trusted, as they could be subject to manipulation by experts, policy makers, or interested groups. Perspectives for the solution of such problems are offered by post-normal science (Funtowicz and Ravetz, 1993), which recognises that scientific and technical discourse should be opened to non-experts (stakeholders and the general public). Only accepting the challenge of opening these “black boxes” by involving the interested actors in the conceptual formulation of the tools can we expect concrete potentials for their future use and, in particular, for the process of implementing the principles of IWRM in the real world.

Over the past decades, quite often DSSs were seen as computer shells to provide user interface to models, and potential end-users were not involved in the development or testing phases. With the increasing importance of public participation in decision-making, efforts were made by researchers to involve the potential end-users of the software in the development process, but involvement was still limited in practice. Recognising the shortcomings of the earlier approaches to DSS development, researchers are now increasingly including end-users and stakeholders' input since the early stages of design.

A notable shift has thus occurred, with emphasis moving away from the coding of DSS *tools* to the *process* of developing these tools through participatory approaches. Participatory modelling, therefore, becomes a crucial component of DSS development, with particular attention to ways in which DSSs could be of use for communicating during the decisions process and/or helping finding a compromise solution with the participation of the interested actors. Participatory modelling thus entails the active and direct involvement of stakeholders in model formulation, helping identifying the components of the model and providing inputs to it.

This approach to decision making, combining "soft" and "hard" sciences, is receiving increasing support (Mendoza and Prabhu, 2005; Richards *et al.*, 1995), as the tools for river basin planning may be of greater use to IWRM when developed and applied through a participatory process. This holistic interpretation of "modelling as a process" strengthens the need for participatory modelling, and DSSs can be seen as suitable approaches for providing inputs to facilitate and promote it. DSSs should however be considered in their more innovative and comprehensive definition, no longer as tools aimed at providing "the correct answer" or at identifying the best option among a set of alternatives, but rather as offering methodologies and strategies to support and manage the decisional process in all its stages.

Besides its evident potential, participatory modelling still presents many challenges to both the scientific and the policy communities. To the scientists, it requires the development of novel methodologies and tools for model design and implementation in a participatory context. Policy makers need to invest significant resources for facilitating the development of the new models, and for participating in the process itself. It is however our belief that such efforts are worth for both communities, given the current situation of limited exploitation of research outputs and the clear need for improving the quality of policy and decision making, as required by the most recent evolution of policies and legislation.

THE MULINO EXPERIENCE WITH MODELLING AND DECISION SUPPORT FOR IWRM

The contribution of the MULINO project to participatory modelling

MULINO was part of the EU's efforts to develop operationally useful DSS for IWRM, and was set within the context of the EU water policy, as defined by the WFD. The project – which began in 2001 and was concluded at the beginning of 2004 – had the main objective of addressing the existing gap between researches and policy makers with respect to the development and use of DSS tools for IWRM, through the design and implementation of an operational decision support system for the management of water resources. The tool could be based on hydrological modelling, multi-sectoral indicators, and a multi-disciplinary criteria evaluation process, and was intended to provided a framework to integrate quantitative with more qualitative information. The methodology was expected to contribute to the quality and transparency of decision making for the development of River Basin Management Plans, whenever a solution has to be selected within a discrete set of alternative options.

The main tangible result of the project is a stand-alone DSS software, *m*DSS, which is freely available from the project web site, and provides functionalities to support the integration of socio-economic and environmental modelling techniques with GIS functions and multiple criteria decision methods.

When exploring participatory modelling as an indirect means to comply with the WFD requirements of participatory planning, the most relevant aspects of the MULINO Project are the methodology and process within which *m*DSS was developed. In an attempt to bridge the observed gap between DSS development and application, a two-pronged strategy was used: (i) first, a participatory development approach was taken right at the outset through the involvement of potential end-users in the tool development phase; (ii) secondly, the methodology and software were developed for application under a variety of conditions and different spatial scales. The test in 5 countries and in one pan-European application demonstrated the flexibility of both the process and the resulting tool.

The main components of the MULINO approach – which takes experts, end-users and selected stakeholders through the steps of building the decision with the support of *m*DSS – are illustrated in Figure 1 (for a more detailed description of the methodology and the software, see Giupponi, 2006 and Mysiak *et al.*, 2005).

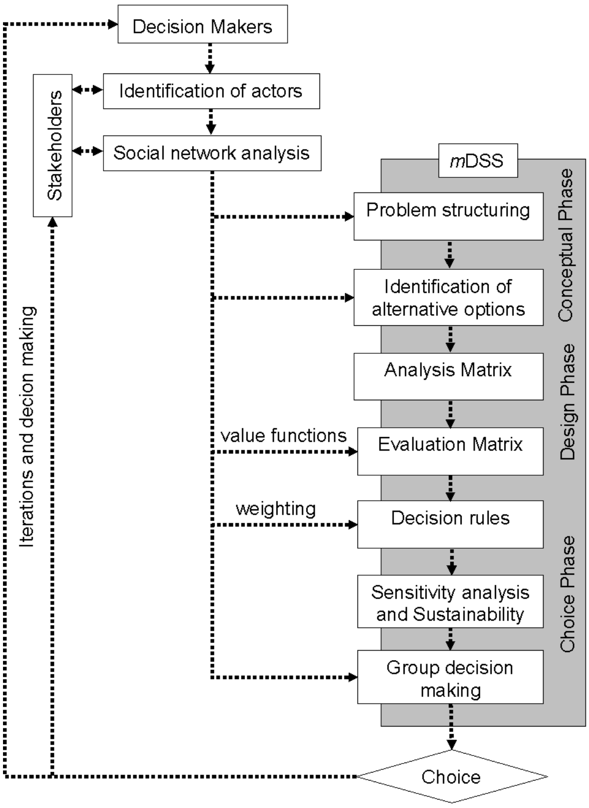

Fig. 1: Participatory approach developed by the MULINO Project (from Giupponi, 2006).

At the beginning of the process, a Social Network Analysis is undertaken, with the purpose of identifying the key stakeholders to involve in the modelling exercise, as well as their relational ties. In the application of MULINO, a methodological approach for the analysis of local networks in the context of IWRM is provided, and applied to the decisional context in the case study. The methodology serves first of all to identify the role played by local actors, but also to involve them in the implementation of the project, and establishing local network of stakeholders in the case studies of reference. A comparison across the MULINO applications highlights how the dimension and density of the network are correlated, and how, in larger network, actors' centrality (and thus their power) seems to be more unevenly distributed. This consideration is important when establishing water management policies, but also and foremost when planning for public participation (for additional details, see Lourenço *et al.*, 2004 and Feás *et al.*, 2004).

After the preliminary identification and involvement of stakeholders, in the *Conceptual Phase,* (i) the exploration of the decision problem, (ii) the identification of alternative options to address it, and (iii) the selection of key indicators take place, with active participation of both decision makers and selected stakeholders. The Conceptual phase represents the MULINO attempt to implement participatory modelling in decision making, when the problem to be addressed is "modelled" with the help of key indicators and the sketching of causal ties. At this stage, models are represented by mental maps which provide the structure of the problems to be addressed, and the relational ties linking each factor and issue pertaining to the problem itself. To facilitate and structure participatory modelling, the process is based upon an intuitive and easy-to-grasp approach, the Driving Force-

Pressure-State-Impact-Response (DPSIR) framework (EEA, 1999). This approach produces a formal description of activities and issues relevant to the management of water resources, making explicit the causal chains relating human activities and the state of the environment. The DPSIR framework, therefore, supports the process of participation though mental modelling, implementing a system analysis approach, answering to the users' need for more structured and formalised external models. This is achieved through the capacity of the DPSIR framework to simplify the understanding of the complex relationships between the drivers of environmental problems, their impacts, and society's responses to them. This schematisation highlights the causal links between interacting components of social, economic and environmental issues relevant for the management of resources. The DPSIR methodology is a powerful tool for participatory modelling, offering a simple structure to share individual cognitive maps of a system, and facilitating the process of arriving at a shared view of the problem.

The *Conceptual Phase* then provides the ground for implementing physical and socio-economic mathematical models in the subsequent *Design phase*.

During the *Design Phase*, end-users identify options, and produce an analysis matrix with a process of integrating various data sources – outputs of physical and socio-economic models in particular. Finally, in the *Choice Phase*, the normalisation and weighting of the multidimensional data stored in the analysis matrix take place, leading to the evaluation of the options that are thus compared and ranked.

The selection of the final choice is based on the application of Multi-Criteria Decision Methods (MCDMs), which allows the comparison of alternatives and their performances with respect to pre-defined and agreed evaluation criteria, and their relative importance (i.e. weights). The *m*DSS tool provides for more than one decision rule to aid the process, and includes the possibility of parallel implementations of the *Choice Phase* to allow for group decision making in a participatory context: in this case, actors may individually or in group apply their own valuing and weighting decisional criteria, which are then combined in a final stage where group decision-making routines are implemented. All the steps of the decision process are stored in documentation files allowing for transparent communication of the subjective judgements and preferences expressed by the users and combination of multiple parallel processes in a multi-stakeholder context.

Lessons learned and further research developments

From the methodological and empirical applications of DSSs, it emerges that the process of model development has assumed a central role, as opposed to the model itself as a pre-existing tool. As such, it is participatory modelling which may more directly and immediately support policy makers in implementing participatory planning in the context of IWRM in general, and the Water Framework Directive in particular.

As illustrated in the preceding sections of the paper, the process of participatory modelling is central to the MULINO methodology, and it is based on the use of a rather intuitive and easy to communicate framework, DPSIR. Despite the notable progress, however, the management of stakeholders' involvement is still poorly organised and supported, and so is the selection of the stakeholders to take part in the process (see, for instance, the case studies reported in Hare *et al.*, 2006). Research developments after the end of the MULINO project were focused on maintaining the development of the software but the greatest emphasis was placed on the structuring of the decision process and the provision of methodological solutions and identification of possible tools within the newly developed NetSyMoD methodological framework (Giupponi *et al.*, 2005).

There are various strategies for improving participatory modelling, such as providing end-users methodological support for the selection of key stakeholders through the implementation of network analysis techniques, and using cognitive mapping techniques for eliciting stakeholders' views of the problem, in combination with the DPSIR conceptual framework. Stakeholders and Social Network Analysis (see, e.g., Wasserman and Faust, 1994) can be fruitfully used for the identification of stakeholders, and the results integrated within the design of the DSS tool. This would ensure that the selection process is carried out in an objective manner, ensuring that no key stakeholders are left out, and that those taking part are truly representative and can meaningfully participate. Participatory seminars and elicitation techniques can provide an objective and reliable way to elicit mental maps from the stakeholders, therefore responding to the explicit need of the policy makers' community of moving from haphazard stakeholders' participation to structured participation over long time periods (Hare, 2004a, and Hare, 2005). Various cognitive mapping techniques are available, such as the hexagon method (Hodgson, 1992) and causal modelling (Vennix, 1996).

Despite the early stages, participatory modelling seems to offer a good methodological approach to participatory planning and managing, and further efforts are likely to be well invested in this field. Nonetheless, some open questions require adequate consideration:

- What incentives can be presented to policy makers in order to ensure that it is worth for them to invest in acquiring knowledge of participatory modelling techniques and/or DSS tools?
- How can the training requirements of potential end-users be best addressed?
- As building DSS tools is a resource-intensive exercise, is it possible to develop a tool based on participatory modelling processes, which is representative of many different situations and can, therefore, be safely used in different circumstances?
- Which avenues do researchers have to develop new methodologies and tools with a higher probability of finding an actual use in decision-making exercises? Should the DSSs tools be simplified as much as possible to favour their use, or should their technicalities and complexities be maintained?

These conclusions may not be entirely new, as these questions have been discussed in the literature for quite some times (see, for instance, Chapter 7 and 8 of Giupponi *et al.*, 2006, and the references therein). Yet, it seems very clear that empirical applications often do not give them appropriate considerations. It is thus worth reiterating that finding suitable ways of addressing these concerns would significantly contribute to the improvement of public participation in IWRM, and will be discussed in more details in the remainder of this section.

As highlighted by the Harmoni-CA Synthesis Workshop (Hare, 2005), "the lack of use of models by policy makers and the lack of participation in management both have the same root cause: the lack of incentives to do so.": triggering the process of model and DSS adoption by potential end users remains critical. We propose here two possible ways in which policy makers could be motivated to invest in training:

- a *regulatory* approach, by which using participatory modelling and tools becomes a legal requirement, embedded in national and/or European policies;
- a *needs* approach, in which policy makers are indirectly induced to use participatory modelling and tools, adopting a two-pronged strategy: highlighting the medium to long-term benefits of PP (especially in terms of reduced conflicts and enforcement costs), and through the development of tools and methodologies addressing exact legislative requirements and reporting rules.

Adequate capacity building and training of potential end-users is necessary to ensure the process is not mismanaged, or the tool misused[3]. One of the major barriers to policy makers using models is the complexity of the models themselves, which need a large investment of time and human resources to understand and master. Policy makers are thus required a thorough knowledge of elicitation techniques and software use. Three main strategies are suggested to improve capacity building:

- strengthen the role of trained professionals acting as facilitators in the participatory planning process. Such a professional background should find more attention in the curricula offered by European universities;
- promote an extended campaign of in-house expertise development enabling policy makers to meaningful undertake participatory planning, and using modelling tools for decision making. For this strategy to be effective, however, one would need to find a "normative" entry point;

[3] The need for well developed expertise to participate in the processes and profitably use DSS tools emerged not only during the assessment of the MULINO project, but also within the Harmoni-CA activities. Between 2003 and 2004, as part of the Harmoni-CA project, a series of interviews were conducted with policy makers engaged in implementing the WFD. Even though the interviews referred to models in the general sense, rather than to DSS specifically, the findings are useful in this context as well.

- increase research efforts on developing tools and methods for the use of *consultants*, who would then provide external support to decision makers. Before investing substantial resources along this path, careful consideration should be given to the financial constraint in which many policy makers find themselves operating.

Early involvement of end-users and stakeholders is often advocated for as a means to ensure that the tools are used in actual decisional processes and, therefore, address the needs and requirements of decision makers. Yet, there is a trade-off between the extent of early involvement and the extent to which the tool can be re-used. Indeed, as far as models – and DSSs – are equated to computer tools, the issues of usability and re-usability become crucial (McIntosh *et al.*, 2004). Modularisation of tools within a coherent and general methodological framework may represent an effective strategy.

Finally, one of the limits of models often highlighted by policy makers is their relative complexity – be a model intended as a mathematical representation of reality, or as a process of building a mental map of reality. It is therefore quite tempting for researchers to simplify their tools and methodologies, with however the risk that excessive simplification will lead to biased – or outright wrong – results and advise. Simplification of existing tools and methodology should therefore be seen only as a second best solution, while layered modelling systems, meta-models and improved interfaces and communication tools should be preferred.

CONCLUDING REMARKS

The Mediterranean basin is characterised by a strong heterogeneity of cultures, economies, and societies. This diversity – which is both north-south and across countries on the same shore – has been named as a key contributing factor to the present economic marginalisation of the southern bank: only three of the 12 Mediterranean partner countries in the Southern bank have income levels similar to those of some EU countries, and they account for almost one fourth of the region's GDP. This marked heterogeneity has also often implied problematic interactions between Mediterranean countries, both bilateral and multilateral, and to instability in the region, problem which is more acute for the management of transboundary issues, such as trade, pollution, and water.

The environment in the Mediterranean basin is characterised by low resilience, aggravated by the insufficient attention paid to environmental issues during fast industrialisation, both in the southern and northern sides of the basin. Moreover, the political and institutional capacity for environmental policy remains low, especially in the south.

Water resources are scarce in the Mediterranean area, and yet the current management regimes are at times neither efficient nor sustainable. The need to improve on the current system is paramount, if the objective of sustainable development subscribed by partner countries and the EU, and stability in the region, are to be achieved and maintained. Within this context the EU launched the *EU Water Initiative (EUWI): Water for Life*, with a specific Mediterranean Component (MED EUWI) aiming to:

- assist design of better, demand driven and output oriented water related programmes,
- facilitate better coordination of water programmes and projects, targeting more effective
- use of existing funds and mobilization of new financial resources and,
- enhanced cooperation for project's proper implementation, based on peer review and
- strategic assessment.

The main reference for the EU approach to water policy and management is the Water Framework Directive (EC/2000/60), whose principles are brought also to international cooperation efforts such as the MED EUWI.

IWRM requires public participation as one fundamental component of sustainable management of water resources, enabling the integration of the social and political spheres of resource planning. The requirement for participation in planning and management is also enshrined in the main European references and initiatives, such as the WFD and the MED EUWI.

The implementation of the declared principles in the practice of IWRM plans however imposes on policy makers the burden of undertaking consultation and participatory planning and management, without providing adequate indications of how this can be achieved. This is particularly true in the Mediterranean area, where the practice of PP is relatively newer than in northern countries. Hence, policy makers are left with a three-faceted problem: first of all, how to select all relevant stakeholders in an objective and transparent way and to do so in a manner which ensures results are a true reflection of the public, as well as respecting sustainability criteria. Secondly, how to constructively involve the identified stakeholders – hence managing their inter-relations, interests, etc. And, finally, how to integrate their opinions, concerns, desires in the planning process together with technical and scientific information coming from various sources, such as monitoring systems and, in particular, various kinds of disciplinary simulation models, in a manner which is transparent and manages to compromise among objectives and to build consensus.

Models are often cited as one possible avenue to improve water resources management and planning. Within the broader meaning of the term, models include mental maps and external representations of internal interpretations of reality – thus moving away from hard-fact, objective formalisations to include the process of developing models and building tools. Participatory modelling can provide a means to link mental models to mathematical models, and DSSs are the tools which can be used to explore the feedback loops with participated decision-making. Further strengthening this view is the realisation that traditional DSS focusing on modelling and the computation part of decision process have consistently failed to consider the “soft part” of the decision making process, and thus problem structuring and conflict mitigation. These latter activities cannot be translated into computer codes, but are of course integral and important parts of problem management and decision-making, and can be integrated within a participatory modelling framework.

It is the process of participatory modelling which can more readily and effectively support participatory planning for IWRM and, in the European context, for the WFD. Yet until research and policy find a common ground, this potential will remain untapped. Some general lessons can be drawn from the experience described in this paper:

- models for participation need to be understood in a much more general way, as a process of engaging both decision makers and the general public to make participation worthwhile.
- there is a strong need for scientific and technical support for the meaningful involvement of stakeholders in planning and implementation through participatory modelling.
- in order to bridge the gap between models as tools and actual decisional processes, one needs to move on to the next stage of “model” development, where the tool is developed with heavy involvement of end-users and stakeholders through participatory modelling, and it is geared to addressing their priority needs.
- yet, there is a trade-off between specificity and re-usability of both participatory planning methodologies and the resulting tool, thus requiring flexible and, possibly, modular approaches to be developed.

The experience with MULINO represents one of the first attempts to address some of the issues mentioned, demonstrating however that the barrier between research and policy has not been broken yet. The challenge remains of how to trigger the process of collaborative development and adoption of the proposed methodologies by potential end users. Mutual learning between scientists and policy makers may then help to make the process of participatory modelling general enough to be applicable in a diversity of contexts, and with different models, but at the same time with enough scientific robustness to ensure its usefulness in structuring the problem and identifying a range of possible solutions. Such a methodology, with the support of integrated modular tools, should cover all aspects of participatory management – from the identification of the relevant stakeholders to the methods for integrating their concerns in the final choice – and would provide sound advice and technical/scientific support for policy makers, to implement a concept as elusive as that of participatory planning, which remains a requirement of the IWRM. Otherwise, the risk is that participation will remain just another “buzz-word”, with the consequent failure of harnessing its huge potential benefits in terms of improved decision-making.

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