Building up the Science in the Art of Participatory Modeling for Sustainability

Nuno Videira, Paula Antunes, Rui Santos
ECOMAN – Ecological Economics and Environmental Management Center
DCEA-FCT, New University of Lisbon
Quinta da Torre, 2829-516 Caparica, Portugal
Tel.: +351 212948300; Fax: + 351 212948554
E-mails: nmvc@fct.unl.pt; mpa@fct.unl.pt; rfs@fct.unl.pt

Abstract

Following several calls for participation in environmental policy, an increasing attention is being dedicated to the development of deliberative platforms for the sustainable governance of our global village. In this paper, we start by adding perspective on the role of participatory modeling within a strong participatory vision for sustainability. We then explore how system dynamics and ecological economics worldviews interlock in promoting participatory modeling approaches to environmental decision-making. Focusing on the synergies between group model-building and mediated modeling, some lessons from two participatory interventions developed in Portugal are extracted. The evaluation of the case studies indicates positive outcomes at the individual and group level, with respect to learning, reaction, commitment, communication and consensus. The outcomes at the organizational level are still more limited. Further research is suggested on the comparison and complementarity between participatory modeling and other deliberative methods.

Keywords: participatory modeling, group model-building, mediated modeling, system dynamics, ecological economics, Ria Formosa, Baixo Guadiana

1. Envisioning a strong participatory approach for sustainability

Multi-dimensional, pluralistic and integrative concerns are on the forefront of the sustainability debate. As stressed by the working definition proposed by Costanza et al. (1991, p.8) "sustainability is a relationship between dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems, in which human life can continue indefinitely, human individual can flourish and human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the ecological life support system". Hence, the new role of policy-makers requires the facilitation of learning and the identification of leverage points with which to direct progress towards integrated economic, ecological and sociocultural approaches for human activity (Meppem and Gill, 1997).

In the sustainability learning path, policy-makers have been called to accept society on board. Thirteen years since the Rio Declaration on Environment and Development heralded the participatory principle[1], several appeals for participatory approaches to sustainable development have been placed. For example, in the United States, institutional support for new collaborative decision processes has been recognized by

[1] "Environmental issues are best handled with participation of all concerned citizens, at the relevant level... each individual shall have appropriate access to information concerning the environment that is held by public authorities and the opportunity to participate in decision-making processes..."(UNCED, 1992).

the President's Council on Sustainable Development (PCSD, 1996). In Europe, many agreements and EU directives[2] have included provisions for participatory input to environmental decisions. While more and more decision-makers in democratic societies are recognizing the right for public and stakeholder involvement in environmental policy, many scientists are investigating best practices in bridging the gaps between policy and society. But what is the added-value of inviting society groups to collaborate in the definition of the rules which determine decisions? Figure 1 takes stock of many contributions to this debate (Bandura, 1977; Bear, 1994; Beirle and Cayford, 2002; Costanza, 1999; Hare et al., 2003; Holmes and Scoones, 2000; Petts, 2003; Prugh et al., 2000, Yearley et al. 2003) by formulating a vision of a strong participatory approach to sustainability.

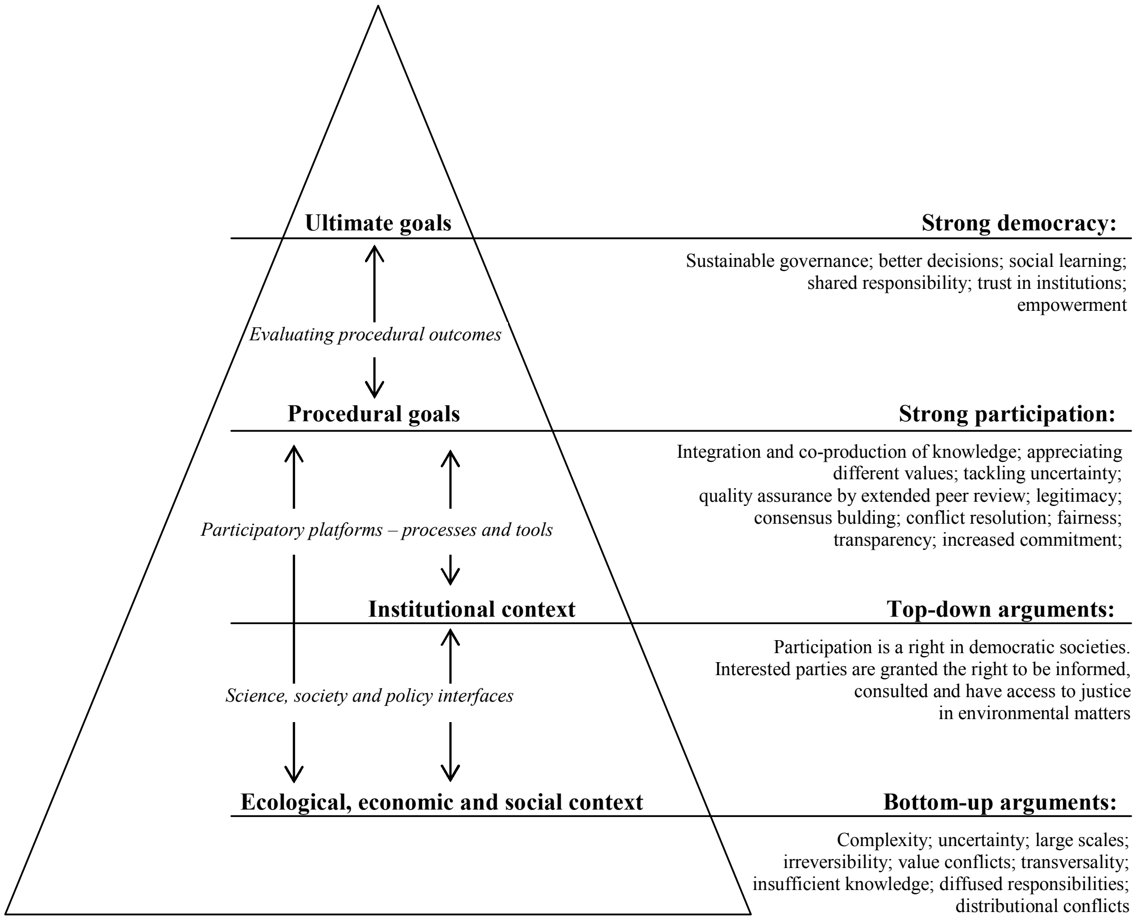


Figure 1. A strong participatory approach to sustainability[3].

[2] For instance, see the Aarhus Convention Convention on "Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters" (United Nations Economic Commission for Europe), the Water Framework Directive (2000/60/EC), the Strategic Environmental Assessment Directive (2001/42/EC) and the Participation Directive (2003/35/EC).

[3] This diagram is indebted to the framework for sustainable development indicators presented by Meadows (1998).

The new rhetoric of participation is sustained by arguments that arise from the institutional context (decision-makers say "we are granting interested parties the right to participate in environmental decisions"). As stressed by van den Hove (2000), the justifications for these institutional calls for participation may be found in the ecological, economic and social context of environmental problems. She argues that environmental phenomena are complex (due to non-linear dynamics and multiple interrelationships), scientific uncertainty abounds, problems have large scale consequences and damage may be irreversible. Deliberative decision-making processes are urgent also because on top of physical complexity, environmental problems are characterized by conflicts between implicated actors, impacts spill over to many society sectors, responsibilities are diffused across scales and the distribution of benefits and costs is uneven (Stave, 2002; van den Hove, 2000). Other discourses supporting participatory environmental management have focused on the goals that may be achieved through deliberative platforms (Beirle and Cayford, 2002; Holmes and Scoones, 2000).

We argue that the new processes and tools that are being investigated aim for achieving "strong participation" as opposed to traditional "weak participation" processes. Old paradigms relied on what Kapoor (2001) refers to as "mainstream" approaches to environmental management, where nature was managed as a "resource" by centralized and hierarchical bureaucratic institutions deploying "efficient" technological means to restrain unfettered economic growth. Within this backdrop, participatory inputs to environmental decisions, if any, were traditionally based on paternalistic and confrontational modes, according to which decision-makers led consultation or litigation processes to meet their specific government needs (Bear, 1994). Alternatively, strong participatory processes are more ambitious, in the sense that they claim for higher levels of participatory impact on decisions[4]. The underlying premise is that strong participation fosters integration and co-production of knowledge, appreciation of different values, management of scientific uncertainty, quality assurance by extend peer review, legitimacy, consensus-building, conflict resolution, fairness, transparency and increased commitment towards decisions. Nevertheless, according to this organic vision, participation is not a goal in itself, but an intermediate means to achieving "strong democracies" (Prugh et al., 2000), in which sustainable governance arises through social learning, decisions are better (or at least better informed), and institutions and civil society share responsibilities and power in a trustful manner.

Participatory modeling is emerging as one of the possible platforms to facilitate public and stakeholder participation in environmental decisions. In this paper we investigate the role of participatory modeling platforms based on system dynamics in contributing to strong participatory processes. The next section presents a brief outline of system dynamics and ecological economics approaches to modeling problems interfacing human, ecological and economic systems. Both disciplines have developed participatory lines of research, which share the system dynamics method but present a few differences which have deserved our attention. Thus, we have investigated possible synergies and tested some new hypotheses for gaining more insight on how to increase the effectiveness of participatory modeling for sustainability. Our findings are

---

[4] This refers to a participatory continuum which starts with low levels of impact such as public and stakeholder information/consultation and progresses to involvement, collaboration in policy design and empowerment of the interested parties (IAP2, 2000).

illustrated with two case studies developed in Portugal. Section 3 outlines the characteristics of these projects and section 4 discusses in more detail the achieved results. The final section closes with some broad conclusions.

2. Frontiers in system dynamics and ecological economics participatory modeling

The powerful method developed by Jay Forrester in the 1950's is grounded in the theory of nonlinear dynamics and feedback control and constitutes an interdisciplinary approach to solving dynamic real world problems. In a nutshell, **System Dynamics (SD)** is a fundamental and structural method to sustain the ability of learning in and about complex systems (Sterman, 2000).

Ecological Economics (EE) has emerged in the late 1980's as a transdisciplinary field of study that addresses the relationship between ecosystems and economic systems, in the broadest sense (Costanza et al., 1991). In the pursuit of sustainability, ecological economics has promoted innovative research streams such as valuation of natural resources and natural capital, ecological economic systems accounting and the development of new environmental management instruments (Costanza et al., 1991). Ecological economics is also concerned with the development of an integrated, pluralistic and transdisciplinary approach to modeling at local, regional and global scales (Costanza, 1991).

SD and EE transcend scientific boundaries and recognize the need for a dialogue between different disciplines, methods, and values in order to overcome the barriers to learning (Costanza and Jørgensen, 2002; Sterman, 2000). As such, their own fields have interlocked in a variety of ways.

The EE modeling approach studies the interrelationships between ecological and economic systems with a focus on integration and plurality of methods and problems. Several EE works describe the development of integrated models using system dynamics software, predominately Stella. For instance, in more recent articles, Low et al. (1999) describe the linkages between ecological and economic systems while exploring the dynamics of fisheries harvest patterns. Boumans et al. (2002) presented a global unified model of the biosphere (GUMBO) to simulate the integrated earth system and assess the dynamics and values of ecosystem services. Eppink et al. (2004) developed a dynamic simulation model of the interaction between wetland biodiversity and land use. In EE dynamic modeling, some of the SD principles are used to tackle the complexity of environmental problems, arising from nonlinearities, spatial/temporal lags and bounds on human rationality (Costanza and Ruth, 1998).

In a recent analysis of SD applications to environmental and resource systems, Cavana and Ford (2004) stress the increasing interest that system dynamicists have been devoting to these issues. Several works focusing on environmental modeling principles (Hannon and Ruth, 1994; Ford, 1999; Deaton and Winebrake, 1999) and practical applications (Ford, 1996; Ford, 1997; Sudhir et al., 1997; Saeed, 1998; Randers, 2000; Moxnes, 2000; Sterman and Sweeney; 2002; Fiddaman, 2002) have covered a wide range of themes such as electricity production, solid waste management, water resource management, sustainable development and climate change, just to cite a few examples. Given the multiple dimensions of environmental problems, modeling environmental and resource systems usually implies the integration of ecological, economic, social and technological concepts. At larger scales the need for integration becomes more evident, such as demonstrated by the work on global models and the limits to growth in a finite world (Forrester, 1971; Meadows et al., 1972; Meadows et al., 1992).

Integrated models of large systems require input from a broad range of people and appropriate group modeling designs for building consensus and mutual understanding about the way the system works (Costanza and Ruth, 1998). This poses the question on how much structure needs to be added to the modeling process in order to incorporate the different sources of knowledge (from quantitative data to the mental models of individuals and groups) (Vennix et al., 1992). Over the years, SD and EE have answered by developing a participatory modeling dimension, with methods such as **Group Model-Building (GMB)** and **Mediated Modeling (MM)**, respectively.

GBM has been referenced for more than a decade as a method for tackling messy problems, fostering consensus and commitment through work in management teams. It addresses problem structuring in order to create concerted action and has been extensively tested in the study of organizational messy problems with client groups in private and public institutions (Richardson and Andersen, 1995; Vennix, 1996; Vennix, 1999). Applications of GMB to sustainability issues are more limited (Stave, 2002; Stave, 2003).

MM involves broad stakeholders groups in the development of scoping models of complex problems and has been applied to ecological economics issues (van den Belt, 2004). This method was developed in the late 1990's and aims at fostering environmental consensus and collaborative team learning experiences (van den Belt et al., 1998). The contributions of MM toward solving complex environmental problems are related with integration, participation and intertemporal linking (van den Belt, 2004).

Table 1 summarizes the main characteristics of GMB and MM applications to sustainability related issues. It may be observed that the two methods share participatory goals. On the other hand, it may be argued that synergies between the methods could be further explored with respect to the problems addressed, modeling tools (e.g. exploring the role of qualitative modeling) and some elements of the process design.

Some clues for future research in GMB and MM have also been highlighted by the reported experiments. For instance, van den Belt (2004) recommends improving system dynamics analysis of mediated models (e.g. feedback and time lags) and improving small group work. Moreover, in order to allow for the comparison between participatory modeling and other deliberative approaches we may add other research topics, namely stakeholder analysis and representation issues, assessing quality of information used and improving performance measurements.

Building on the findings from previous research in GMB and MM, the following sections report on the two participatory modeling projects that have been implemented in the Ria Formosa Natural Park and in the Baixo Guadiana river basin.

Table 1. Comparison of group model building and mediated modeling applications to sustainability related problems.

	Group model building	***Mediated modeling***
Fundamental assumptions	It constitutes a system dynamics approach to modeling for learning about organizational problems. System dynamics provides an improved public involvement framework by focusing on problems, seeking problem causes in system structure, focusing on policy levers, providing a feedback tool for learning and policy design and documenting the participatory process (Stave, 2002).	It constitutes an ecological economics approach to modeling, which is based on system dynamics to construct computer-based simulation models at the scoping level (van den Belt, 2004). Scoping is understood as the first step in a three-step process (Costanza and Ruth, 1998), which leads to research and management models, as more effort is put in model resolution (van den Belt, 2004).
Participatory goals	Aims for promoting learning and improving systems understanding by integrating relationships at the appropriate scales – changing mental models and gaining insight through surprise. Provides a neutral framework for discussion and a platform for consensus (Stave, 2002).	Aims for a collaborative team learning experience to raise the shared level of understanding in a group and to foster consensus about worldviews, decisions and/or commitment towards decisions (van den Belt, 2004).
Problems addressed	• Indicators for sustainable development in a natural park (Kelly, 1998a); • Transportation and air quality management (Stave, 2002); • Water management (Stave, 2003) • Resource sustainability in commodity systems (Jones et al., 2002)* Note: the authors did not use specifically the term “group model-building”, having worked with interest groups for model development and facilitated workshops with stakeholders	• Coastal zone management (Costanza and Ruth, 1998; van den Belt, 2004); • Material and energy use in the iron and steel industry (Costanza and Ruth, 1998). • Watershed management (Costanza and Ruth, 1998; van den Belt, 2004); • Biodiversity conservation (van den Belt, 2004);
Modeling tools	Qualitative causal diagrams and quantitative system dynamics models.	Focus on quantitative system dynamics modeling with STELLA.
Participatory process design	Large group meetings and small group modeling meetings. Modeling team develops technical work behind the scenes (Stave, 2002).	Sequence of two to four modeling workshops with plenary and small group work. Modeling team performs individual interviews with participants before and after the mediated events and develops technical work in-between meetings (van den Belt, 2004).
Limitations	Participant recruitment (attendance to meetings is voluntary), political and context constraints (pressures for short-term decisions), managing stakeholders expectations (Stave, 2002).	Participant involvement (institutionally driven projects help motivating participant recruitment), dependence on technical aids, and process dependence of the mediated modeler (van den Belt, 2004).

3. Overview of the Ria Formosa and the Baixo Guadiana case studies

The **Ria Formosa (RF)** is a coastal wetland of 18,400 hectares with sandy barrier islands located in the south of Portugal, in the Algarve region. This ecosystem is classified as a protected area under national and international programs[5]. The ecological value of the Ria Formosa lies in its rich biological resources and the fact that it constitutes an haven for many bird species and a nursery area for fish species. Local economic development is strongly dependant of the ecosystem resources and services. The economic value of the area is explored through many activities such as urban development, tourism and recreation, fisheries, cultivation of fish and bivalves, agriculture, salt making and sand extraction. The expansion of urban areas in sensitive zones, the overexploitation of fish and shellfish stocks, the abandonment of salt marshes and traditional activities, the inadequate treatment of domestic and industrial effluents, and the overexploitation of aquifers are just some of the problems affecting sustainable development of this area.

The RF participatory modeling process was initiated by the modeling team under a national research project contract (PNAT/1999/GES/15010) and constituted a follow-up to a previous MM scoping exercise developed in the RF natural park in 1998 (Videira et al., 2004a). The overall project goal was to iterate the scoping model to a more detailed research model which may serve as a blueprint for the development of management plan for the protected area.

The Guadiana is an international river shared between Portugal and Spain with a total drainage area of 6.68 million hectares (17% in Portugal). The Portuguese side of the basin is one of the largest river basins in the country, after Tagus and Douro. The estuary area, often referred to as **Baixo Guadiana (BG)**, has a high nature conservation value. For instance, the Natural Reserve of the Castro Marim and Vila Real de St.º António Saltmarsh was the first area to obtain such classification in Portugal (2089 hectares designated in 1975). This natural reserve located in the BG includes protected habitats and harbours many bird species. In the BG, water plays a strategic role in the development of several activities such as domestic water supply, fisheries, forestry, agriculture, salt making industry, tourism and recreation. The large number of dams built upstream, both in the Portuguese and Spanish sides, affects the water quantities arriving at this southern part of the basin. Conflicts of interests and values occur between landowners (and other project promoters) who wish to promote economic activities and the saltmarsh managers, who strive to preserve the ecological value of the area.

In the BG, the group modeling intervention was also initiated by the modeling team, this time under the ADVISOR research contract (EESD-RTD, EVK1-CT-2000-00074). The ADVISOR project aimed at developing guidelines for deliberative decision-making processes in river basin planning and management, in order to facilitate the implementation of the European Water Framework Directive. Participatory modeling was one of the investigated tools to support such processes. The overall objective of the BG case study was to scope out the relationships between pressures and impacts

[5] It was classified as a Natural Park by the Portuguese government in 1987, a special interest site for nature conservation of the European Natura 2000 network, a special bird protection area by the European Union Directive 79/409/EEC and an important humid area of the Ramsar Convention.

characterizing the main problems in the area. The exercise aimed at developing a shared and integrated view of the Baixo Guadiana problems, in the context of implementation of the Water Framework Directive. The process was also designed to initiate the debate over strategic planning options for the lower Guadiana river basin.

Table 2 presents the main characteristics of the RF and BG participatory modeling processes[6]. More details on the developed models may be found in Videira et al. (2003a) and Videira et al. (2004b) for the RF and BG cases, respectively.

Table 2. Overview of the two participatory modeling case studies.

	Ria Formosa Natural Park	Baixo Guadiana River Basin
Year of development	2002-2003	2003-2004
Total project length	18 months	9 months
Number of workshops	4	3
Total workshop hours	48	18
Average number of participants in workshops	41	32
Modeling focus[7]	Research	Scoping
Systems thinking tools	Stocks and flows	Causal loop diagrams, stocks and flows
Preliminary model use	Yes, a previous mediated model at the scoping level	No
Facilitation materials	Computer, projector, printer, flipcharts, hexagons, workbooks	Computer, projector, printer, flipcharts, hexagons, workbooks
Final deliverables	Model, reports, database	Model, reports
Model sectors	*Quantitative model* - nature conservation value, fisheries, fish farming, bivalve cultivation, tourism and recreation, population urbanization, accessibilities, dredging, pollution control	*Qualitative model* - nature conservation, water quality, tourism *Quantitative model* - Nature conservation, water quality
Model size	303 variables (40 stocks, 65 flows)	177 variables (15 stocks, 20 flows,)
Policy analysis experiments	• Investment in nature conservation and water treatment and its impacts on tourism attractiveness • Implementation of a tourism fund for reinvestment in nature conservation • New licenses for bivalve and fish cultivation activities and evaluating its impact on nature conservation values • Demographic impact on water quality and quality of life • Combination of the several policies	Evaluating the impacts on water quality and the natural capital index of the following management measures: • Construction of a wastewater treatment plant • Improving waste water treatment efficiency • Restoration of saltmarshes • Licensing of new fish farming industries • Licensing of golf courses in the natural reserve • Increasing upstream water abstraction (for irrigation, urban supply, etc)
Process evaluation	Semi-structure interviews with questionnaire before & after, observations	Quality assurance protocol, semi-structure interviews with questionnaire before and mailed questionnaire after, observations

[6] The website http://ecoman.dcea.fct.unl.pt/projects/modelar expands information about the participatory processes

[7] This refers to the three-step modeling stages proposed by Constanza and Ruth (1998). Building on the previously developed scoping model, the RF process aimed at iterating this to a research model, increasing the resolution of the stock-and-flow structure describing the park's management problems.

4. Learning about participatory modeling

In this section we will compare and discuss the results from the RF and BG participatory modeling case studies. As portrayed in Figure 2, we tried to draw learning loops starting from the analysis of previous GMB and MM processes documented in the literature. Building on the existing experience we explain how we designed the two case studies in order to test some new hypotheses on how to improve participatory modeling processes to support environmental policy-making. We will close the loop by discussing the lessons drawn from these experiments and will make some inferences for the future practice of participatory modeling. The pieces of insight gained were divided into five learning loops addressing the modeling process design, stakeholder analysis, preparatory activities, information/quality assurance and evaluation of outcomes.

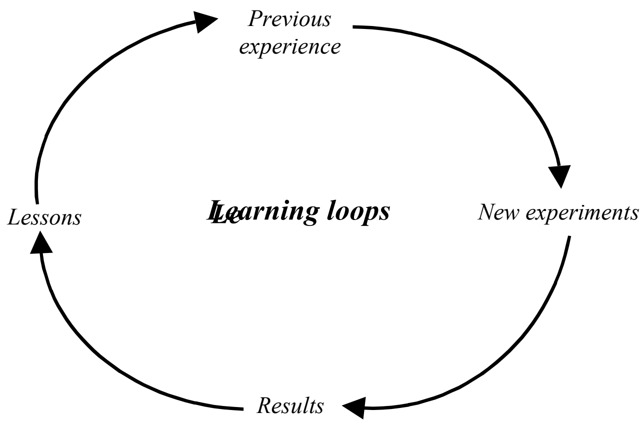


Figure 2. Learning loops in participatory modeling.

Learning loop 1 – Modeling process design

What did previous experience teach us? What did we want to explore? And how?

A participatory modeling process is about enhancing a group's ability to learn about complex problems. But problems and groups are changing all the time and there are no two participatory processes alike. As stressed by Vennix (1996) there is a need for flexibility when applying a participatory modeling method, due to the contingencies of each process, such as the size and composition of the group, the complexity of the problem at hand and time and money constraints. On the other hand, a system dynamics model building process has a core set of steps, which confer a certain degree of standardization. From problem articulation to policy design and evaluation (Sterman, 2000), the modeling steps may be embedded to a greater or lesser extent in different stages of the participatory process. While in some cases participatory input is promoted mainly at the problem definition stage (Costanza and Ruth, 1998), in other cases stakeholders are convened to use and learn about a model that was previously developed (Stave, 2003). Here we will focus on a third possibility, described by van den Belt (2004) and Stave (2002), in which stakeholder groups collaborate in most of the modeling process, thus fostering higher degrees of engagement and insight. Figure 3 illustrates how the modeling steps were included in those participatory modeling experiences.

In the cases described by van den Belt (2004) a MM process is developed throughout three stages. Although there may be differences in the development of each stage, the overall procedure has been consolidated. Most of the modeling steps are performed during a series of workshops designed for group interaction. Nevertheless, a significant amount of effort needs to be developed by the modeling team in-between meetings, especially with respect to the model quantification and validation stages (Videira et al., 2004a). In each MM workshop, small group work alternates with plenary sessions.

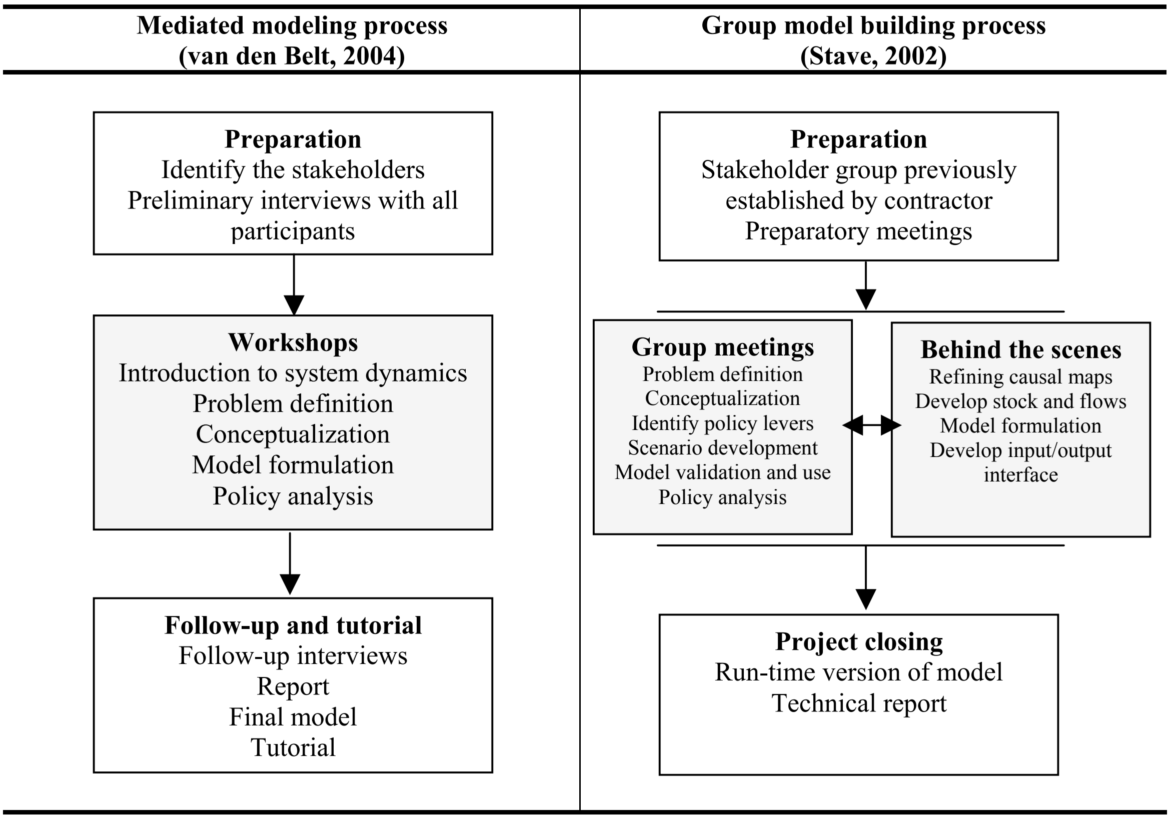


Figure 3. Integration of the model building steps in the participatory process.

In the GMB process described by Stave (2002), the modeling steps were iteratively performed by the modeling team in collaboration with a smaller modeling workgroup, which subsequently consulted and reported periodically to a larger advisory group. Examples of GMB projects developed in other contexts suggest that it is possible to accommodate for different levels of collaboration in the model building stages (Rouwette et al. 2002).

In line with past interventions, the RF and BG processes were planned in three stages: i) setting-up the participatory modeling process; ii) workshops and iii) follow-up. The goal was to develop most of the model building steps during the workshops to promote stakeholder collaboration and interaction.

Since stakeholders participate on a voluntary basis and usually have busy agendas, their availability to participate in many workshops and their pressure for quick answers pull in opposite directions. There was also the indication from previous MM projects that stakeholders tend to decline participation when the projected burden of sessions is too heavy (van den Belt, 2004). Furthermore, when we asked stakeholders in the RF case during the preliminary interviews “What is the worst thing that could happen in the project?”, some answered that it was to participate in disorganized meetings where no tangible conclusions are reached at the end. Hence, our hypothesis was that planning for a limited set of workshops, where group collaboration in the modeling tasks was maximized and the expected results for each meeting were clearly explained, would create a stronger feeling of orientation and ownership, increasing the effectiveness of the modeling process. On the downside, this option reduces the amount of expert modeling effort and possibly the robustness of the model. This trade-off has been addressed by Sterman (2002), who defended that the chances of modeling success increase when modelers work close with clients to find the flaws in their mental and formal models and then work together to improve them.

Finally, when planning for the participatory processes some issues were left undecided, namely the duration of each workshop and the length of the period between workshops. The first topic depended on the number of stakeholders accepting to participate and the progress made in each modeling step. The second issue depended on the amount of work that the modeling team would need to make behind the scenes to prepare for the next workshop.

What were the results? What did we learn?

Table 3 outlines the development of the modeling steps in each workshop of the RF and BG cases. In the RF project four workshops were planned from the beginning but the length of the second and third workshops (two and a half days) was settled with participants of the first workshop, and included four small group sessions (SGS) and a plenary session each. Since the project aimed at contributing to a specific environmental planning process (i.e. initiate debate over a management plan for the park), the model building tasks were directly related with the initial steps of a planning cycle (problem scoping, definition of objectives, generation of alternatives and definition of criteria for evaluating these alternatives). During the first workshop the definition of the problem and the management objectives for the protected area were addressed. In the following meetings the model building process helped in the generation of management alternatives to be simulated by the model. At the policy analysis workshop, the simulation of the impacts of different scenarios on a set of indicators (e.g. water quality, nature conservation values, quality of life index, profit of the economic activities) provided clues for defining criteria to evaluate the alternative policies.

Table 3. Group modeling tasks in the Ria Formosa and Baixo Guadiana projects.

	Ria Formosa Natural Park	**Baixo Guadiana River Basin**
Workshop 1	Problem definition (4 hours)	Problem definition, conceptualization - causal diagram (5 hours)
Workshop 2	Conceptualization (20 hours)	Conceptualization - stocks and flows (8 hours)
Workshop 3	Model formulation (20 hours)	Model use and policy analysis (5 hours)
Workshop 4	Model use and policy analysis (4 hours)	

On the other hand, in the BG we had greater time constraints and have originally planned for only three workshops, addressing problem definition, model conceptualization and policy analysis. The decision of using qualitative system dynamics in the first workshop aimed at testing an alternative design to that proposed by van den Belt (2004) in approaching the development of scoping models. Thus, we have successfully tested a qualitative SD approach that allowed for speeding-up the process of scoping out the main feedback loops, which describe the problem. Hence, in the first workshop participants did not only address problem definition but have also built an integrated causal structure which linked pressures, impacts and policy responses related with the main river basin problems.

To a certain extent, this conceptualization exercise already provided some indications on the positive contribution of participatory modeling in providing a participatory platform for scoping the problems of a river basin, as required by the Water Framework Directive. Nevertheless, a qualitative model does not allow for extensive experimentation, and we decided to use this causal structure as the point of departure for developing a quantitative model in the following workshops. This provided additional insight on the usefulness of the method in supporting early planning stages, where stakeholders are involved in the generation of alternatives, which may feed into a river basin management plan. The quantitative model was conceptualized in the second workshop. Subsequently, the model formulation step was performed by the modeling team in consultation with the participants in-between meetings. At the end, the model allowed for testing alternative policies and the preliminary conclusions were used to draft a list of strategic objectives with associated measures.

In both cases, all the actors considered that the sequence of modeling meetings was effective. The only exception was one stakeholder in the RF project who suggested "for each model sector, model formulation should have been performed in the second workshop, right after conceptualization". The others have commented, "the sequence was logical, structured and effective".

The results of the follow-up questionnaires (see learning loop 3) seem to corroborate our hypothesis with respect to ownership. In the RF project, the average level of agreement to the statement "I contributed to the development of the model" was 3.7 (on a scale of "1-strongly disagree" to "5-strongly agree"). In the BG process, where participants only collaborated in the conceptualization and policy analysis steps, the average score was 2.9.

Learning loop 2 - Stakeholder analysis

What did previous experience teach us? What did we want to explore? And how?

As depicted in Figure 3, some important decisions need to be made prior to the model building steps, the first being the identification of stakeholders that are going to participate. As stressed by O'Neill (2001), the issue of representation lies at the center of recent experiments in deliberative processes concerning environmental problems. According to this author, the issue of adequacy of representation is not primarily an explanatory problem of statistical validity. It is rather a normative problem of political legitimacy where the justifications for the presence of different groups are often unclear.

While discussing the issue of recruitment of participants in a group modeling process, Vennix (1996) and van den Belt (2004) have elaborated on the tension between the quality of representation (which usually requires larger forums) and the quality of deliberation (that tends to improve in smaller groups). To overcome this problem, these authors propose a discretionary approach, according to which it is preferable to include as many participants as those perceived as relevant in a given participatory process. For validating the selection, it may be used a referencing method that allows participants from an initial list to suggest names of further stakeholders (van den Belt, 2004). If large groups are to be achieved this way, this could be balanced by means of increased structure in the group interaction tasks (Vennix, 1996). Adding to this discussion, Stave (2002) points out that using modeling for public involvement in environmental decisions reveals yet another layer of complexity compared to a client-based project developed for a specific organization. This has to do with the fact that as "public participants" are much more loosely bound and usually attend meetings on a voluntary basis, it becomes much more difficult to involve them throughout the whole participatory modeling process.

The analysis of previous projects allowed us to raise some questions on "what" is really being represented in a participatory meeting. Do participants represent different interests? Are they chosen to meet demographic attributes (cf. van den Belt., 2004)? Or are they chosen to include a plurality of values, opinions, preferences and discourses? Or are they already included in a pre-existing group (cf. van den Belt, 2004; Stave, 2002)?

We agree that in a participatory modeling process we should strive for including as much diversity of "mental models" as possible, in order to capture the different types of knowledge and understanding about a given problem. Therefore, we tried to avoid possible biases resulting from a primary focus on the identification of participant names, because this may rule out the worldviews of those traditionally excluded by the power relations in society. Alternatively, we tried to test a combined stakeholder analysis methodology in which institutions, pre-organized groups and their representatives would only be identified after we drafted a map of the different dimensions of the problems at stake. By using this method we expected to gather broad stakeholder groups which could lead to an integrated view of the problems, as opposed to narrowing participation to the more visible or socially respected groups who could only represent a partial viewpoint.

For example, in the set-up stage of the RF project, several meetings were scheduled with gatekeepers from the natural park staff. Since the project was anchored in the five legislated management objectives of the protected area, we first investigated what were the anthropogenic, natural and institutional impact factors (e.g. ecosystem dynamics, economic activities, overlap of jurisdictions, land use plans, etc) which could positively or negatively affect those objectives. This analysis was highly appreciated by managers and created an open atmosphere in which the legislated objectives (that rule the park's activities) were disaggregated into sub-objectives to facilitate the operationalization of possible management measures and instruments. After all the impact factors have been listed, we allocated the types of possible stakeholder groups involved and only then we added the names of participants to be invited. In the identification of the interested parties, we considered several criteria such as the relation of stakeholders with the impact factors, the scale and context at which they usually act, their involvement and accountability (decision-maker, expert, user, victim, etc) and their capacity for engagement in the process. In the majority of cases, the invitations were sent to the top decision-makers in the identified organizations with a reply form in which stakeholders could suggest other names. In some situations, individuals were suggested due to their expertise about a given subject and not because they were part of a stakeholder group or organization, and the invitations were sent directly to the persons in question.

A possible disadvantage of this approach is the risk of ending-up drawing a biased preliminary understanding of the problem, one that represents the views of the gatekeepers and the modeling team and not necessarily that of the stakeholders. This could in turn limit the representation of the group. Combining this with a referencing method, like it was developed in the RF and BG projects, seems to increase the chances of achieving a representative group.

What were the results? What did we learn?

The stakeholder analyses conducted in the RF and in the BG resulted in large lists with 118 and 86 stakeholders, respectively. Table 4 illustrates the types of stakeholders that were identified in each case.

Table 4. Stakeholder groups invited for the participatory modeling processes.

Ria Formosa Natural Park	Baixo Guadiana River Basin
• *National administration*: nature conservation, water, archaeology, sports, development of fisheries and agriculture, ports and marine research • *Regional administration*: environment, economics, agriculture, transports, education, tourism and fisheries, port authorities • *Local administration:* the five municipalities overlapping with the Ria Formosa • *Local associations*: environmental, local development, residents of the barrier islands, bivalve production, business, recreation, tourism, cultural heritage and fisheries • *Local businesses*: tourism, waste and water treatment, fish and bivalve production, salt-making, sand extraction and recreation • *Universities and research institutes*	• *National administration*: water, nature conservation • *Spanish administration*: regional environmental administration, municipalities • *Regional administration*: environment, economics, transports, agriculture, education, port authorities, tourism • *Local administration:* the four municipalities included in the river basin • *Local associations*: environmental, cultural heritage, local development, tourism, hunting, fisheries, forestry, irrigation, social support, navigation, • *Local businesses*: tourism and recreation, water treatment, golf, salt-making, fish farming • *Spanish businesses*: fish farming, tourism • *Spanish associations*: ecology • *Universities and research institutes* • *Local residents*: landowners inside the natural reserve

As depicted in Figure 4, the results from the preparatory and follow-up questionnaires indicated that the stakeholder lists have successfully met the expectations of the majority of participants, with respect to the types of representation they thought were adequate. Nevertheless, the stakeholders declared in the follow-up interviews that the "effective" representation fell short of the "invited". As this was more evident in the BG case, we also asked if the process still managed to include the perspectives of the main stakeholders in the river basin, to which 64% participants have responded positively.

Figure 4 also shows that according to the perceptions of the interviewees the stakeholders have functioned as a group during the workshops, i.e. they worked towards a common goal despite the diversity of parties represented. This perception was stronger in the RF project, where representation decreased less than in the BG case, and participants had more time to work with each other.

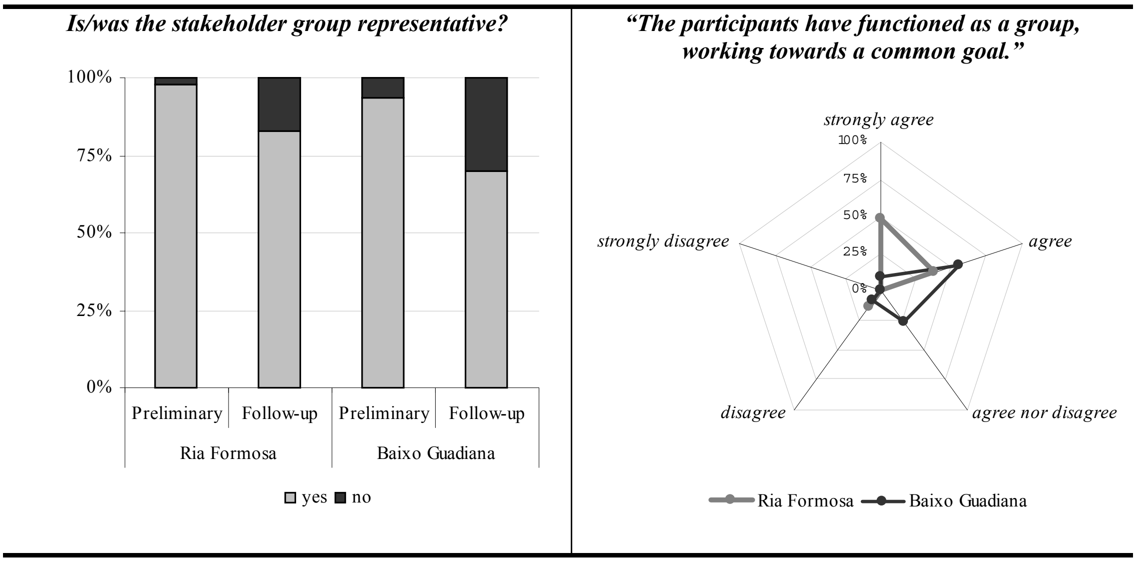
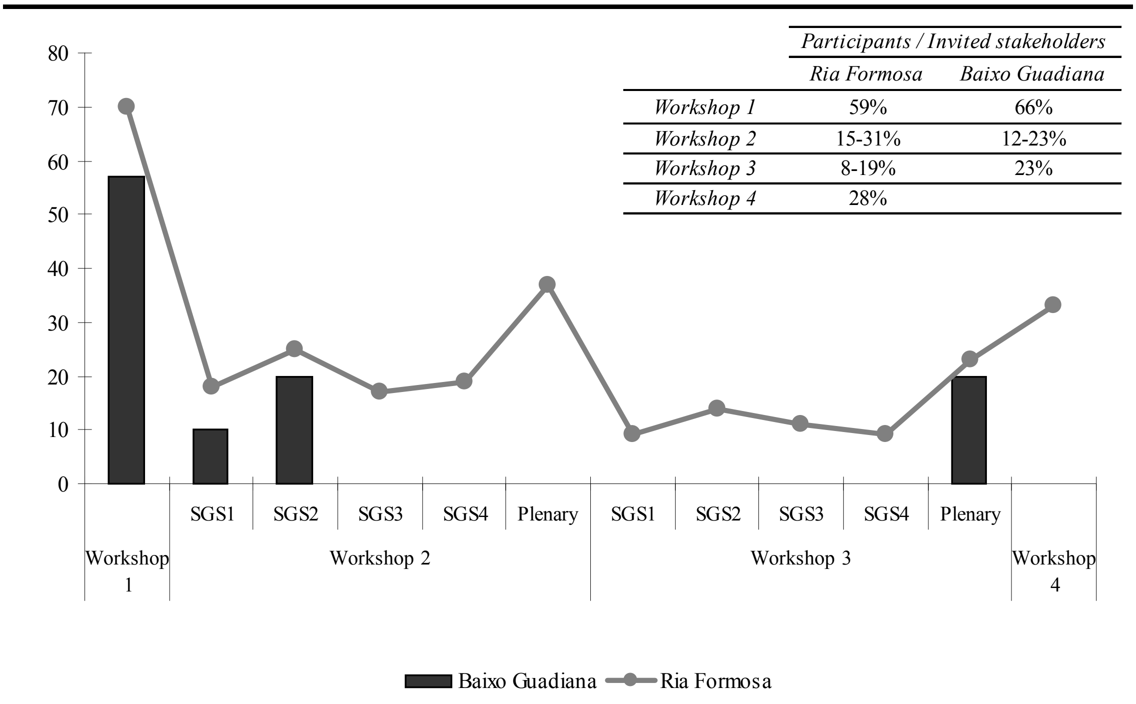


Figure 4. Representation and "groupiness".

The level of participation in each workshop (expressed in the total number of participants and as a percentage of the invitations sent) is presented in Figure 5.



	Participants / Invited stakeholders	
	Ria Formosa	*Baixo Guadiana*
Workshop 1	59%	66%
Workshop 2	15-31%	12-23%
Workshop 3	8-19%	23%
Workshop 4	28%	

Figure 5. Level of participation in the Ria Formosa and Baixo Guadiana workshops.

As the participatory processes unfolded, the levels of participation could never meet the standards of the first workshop. In the RF, five participants have commented that "the initial group was representative although later on some decision-makers did not show up to work", including "environmental organizations, representatives of the tourism and agriculture sectors and some municipalities". In the BG more stakeholders seemed to be dissatisfied with this issue, as expressed in comments such as "the progressive reduction of the group size after the first workshop might have created an incentive for others to leave the process", or "key Spanish stakeholders were missing from the beginning" and "after the first workshop, municipalities and landowners were not represented".

Even though we contacted virtually all participants by phone (after sending invitations by fax or e-mail) to confirm their participation in the second workshop, they never expressed the reasons for not attending on the basis of a negative reaction to the process but rather on agenda constraints. For instance, in the second BG workshop the majority of the stakeholders from nature conservation organizations did not attend because the national administration recruited them unexpectedly. Or in the RF, fishermen said they could not attend because the workshops coincided with the tides schedule. To this extent, further research could investigate the influence of monetary compensation in reversing the dropout rates potentially observed after the inception workshops.

Learning loop 3 – Preparatory activities

What did previous experience teach us? What did we want to explore? And how?

Preliminary and follow-up interviews

Another interesting topic for discussion is the role of individual interviews with stakeholders at the inception and closing stages of a participatory modeling experiment. In the MM processes described by van den Belt (2004), introductory interviews were valuable means for introducing the processes, answering participants' questions, preparing a preliminary model and creating a situational context (e.g. perceived level of conflict and goal orientation). The follow-up questionnaires were used for research purposes in two of the MM projects. The objective was to evaluate change in perceptions at the individual and group level, and to collect participants' opinions about the mediated models and processes. In GMB experiences, the usefulness of individual questionnaires has also been advocated. In the preparatory stage this instrument allows for gathering information to prepare the workshops, improving the modeler's own understanding of the topic and building rapport with participants (Vennix, 1996). At the end of the project, interviews and questionnaires constitute a valuable and objective contribution to evaluate the effectiveness of group model building interventions (Akkermans and Vennix, 1997; Rouwette et al., 2002).

Recognizing the aforementioned qualities of the preliminary and follow-up interviews, we have included them in the design of both cases. The interviews were backed up by questionnaires aiming, on the one hand, at collecting the participants' opinions/values and feelings about the process for evaluating the effectiveness of the interventions. On the other hand, we aimed at further exploring the role of preliminary interviews in gathering information to initiate the process.

Since the purpose of the interviews is usually aligned with the overall objectives of the modeling process, does this lead to having as many interviews/questionnaire designs as participatory modeling experiments? We chose to build on previous designs by including both open-ended and closed questions (Vennix, 1996). The latter were formulated using Likert-type scales and verbal statements to which participants indicated their level of agreement or disagreement. In relation to the types of questions, some sections of the questionnaires were formulated in the same lines of those used by van den Belt (2004) with respect to the analysis of group composition, consensus, ownership and commitment to results. Other sections were newly designed, particularly to explore the role of the preliminary interviews in gathering information to prepare the formulation of the problem. Hence, the questionnaires included specific sections which helped to draw a preliminary map of participants' mental models regarding the problems addressed in each case study.

In the RF and BG interviews we asked about the main factors which have an impact in the natural park and in the river basin, respectively. Subsequently, interviewees characterized those pressures in terms of its spatial distribution (indicating if it was a local or global issue), its trend (which helped in drawing reference behavior modes), its impact magnitude (from severe to low) and irreversibility (from short-tem to permanent damage). In the BG case we did not look only at the pressures, but the whole cycle of the so-called DPSIR indicator framework[8]. Therefore, we collected information which allowed for drawing causal relationships between a problem's "driving forces", "pressures", "changes in state", "impacts" and possible "responses". As discussed by Kelly (1998b) the indicator frameworks for sustainable development, try to capture causal linkages between an environmental problem, but fall short of dealing with the complexity of nonlinear systems. To this extent, we wanted to foster insight through surprise during the workshops (Stave, 2002) by possibly eliciting unanticipated feedback loops in the linear causal chains revealed by participants in the preliminary interviews.

Finally, the questionnaires also challenged stakeholders to think about the opportunities (projects, measures, instruments) they envisioned for the case study areas. Our goal was to collect preliminary indications for defining possible scenarios to be tested at the policy analysis stage.

<u>Roles, scripts and facilitation techniques</u>

The roles performed by the different elements of a modeling team have been thoroughly discussed in the GMB literature (cf. Richardson and Andersen, 1995; Vennix, 1996). These include the gatekeeper, the facilitator, the modeler, the process coach and the recorder. In the conduction of MM projects, van den Belt (2004) acknowledged the differentiation of those five roles adding that they do not need to be assigned to different practitioners, since in some cases "the facilitator/modeler/reflector roles may be merged to keep pace with the speed with which a group reaches a shared level of understanding and a productive level of consensus" (p.50). Thus, this author advocates that a mediated modeler's job can sometimes incorporate all the facilitator, mediator, modeler and process coach roles.

[8] DPSIR stands for "driving forces- pressures- state – impact – response". This framework was proposed by the European Environment Agency for the description of environmental problems. Its use was recommended by the Water Framework Directive Common Implementation Strategy for the characterization of European river basins.

Performing the several roles advocated for a participatory modeling project may be significantly improved by the use of scripts which guide the deliberative actions. Andersen and Richardson (1997) have discussed the importance of developing and sharing scripts for planning GMB processes, scheduling the workshop's agenda, defining the problems, conceptualization, model specification, policy development and project closure.

In designing GMB projects, Vennix (1996) has also discussed the application of other methods that serve specific purposes such as using workbooks in between workshops to summarize the foregoing sessions and prepare for the next, and using magnetic hexagons (Hodgson, 1992) in the Nominal Group Technique (NGT) approach to the conceptualization of a causal diagram.

In designing the RF and BG participatory modeling processes we have build on the experience in GMB and MM, accounting for some of the issues described above. We have tried to create further synergies between the two methods by investigating:

- The relationship between the participatory modeling *roles* and the size of the participant stakeholder group;
- The types of *scripts* that work out well for different modeling tasks;
- The use of hexagons in a NGT approach to develop scoping models in combination with the MM approach;
- The effectiveness of the systematic use of workbooks in-between workshops.

What were the results? What did we learn?

Preliminary and follow-up interviews

In the RF process it was possible to set-up a schedule for conducting 43 preliminary and 29 follow-up interviews. With the BG actors, 32 interviews were performed at the setup stage and 11 questionnaires were returned by mail after the last workshop. In both projects, the preliminary questionnaires were analyzed before the first workshop and the results were presented in the plenary sessions that kicked-off the participatory processes. The participants that had not been interviewed were encouraged to comment on the results and add their viewpoints.

Designing the preliminary interviews to collect information about the problems to be addressed by the modeling process has worked out well in supporting the problem formulation stage. The results from the interviews were presented during the first workshop as a point of departure for discussing about the problems, creating space for deliberation and stimulating divergent thinking by forcing the tension between familiar opinions and diverse perspectives (Kaner, 1996). In the first RF workshop, the questionnaires' results provided the discussion thread for lively interventions from decision-makers with respect to the main pressures in the area and their reference modes. The last section of the questionnaire – the objectives of the Ria Formosa natural park – provided the focus in the discussion: the goal was not to model the RF system and all its problems, but rather to address those factors which work in favor or against the area's management objectives. In the BG case, the information gathered in the preliminary interviews was useful for creating an integrated view of the problem. The DPSIR causal relationships built with each participant were used as a blueprint for conceptualizing the qualitative model. The elicitation of the feedback structure exposed the tension between the linear perceptions of causality revealed in the interviews and the multiple feedback loops drawn in the first workshop.

Roles, scripts and facilitation techniques

The RF modeling team was composed by 5 researchers, all experienced in system dynamics. The gatekeeper from the RF natural park helped in setting up the project, organizing the preparatory meeting and framing the problems. The facilitator and modeler roles were assigned to two different elements of the team but the remaining members rotated the tasks of process coaching and recording group thinking. With large groups in most of the sessions, we found that it was crucial to have two different people performing the facilitator and modeler roles in the RF project. The modeler had a less exposed role, sitting by the computer and building the stock-and-flow model developed in Powersim. As the structure was being projected onto the screen, the facilitator conducted the discussions, stopping whenever necessary to allow for divergent thoughts usually registered on flipcharts, or using a white board to converge arguments into a piece of the model structure. When an agreement was reached the modeler would reproduce that structure in the computer. To some extent, the facilitator was also a modeler. The fact was that he could concentrate on deliberation, giving more attention to the participant's interventions without being distracted by the need to translate them into the computer.

In the BG project, the modeling team had four members. Two gatekeepers from the natural reserve helped to initiate the process. In this case, the facilitator's role was more in line with that of a mediated modeler. No use of the computer was made in the first workshop, and the facilitator deployed the NGT technique with the use of hexagons for developing the qualitative model. This technique has worked out very well; participants responded intuitively to the challenge and have rapidly developed an integrated diagram depicting the BG river basin problems. In the subsequent workshops, the size of the participant group was much smaller and he could easily combine facilitation and modeling tasks. The other modeling team members helped in recording the group proceedings and reporting strategies to keep the group effective.

The majority of the participatory modeling steps in the RF and BG were supported by scripts. We developed most of the types of scripts suggested in the GMB and MM literature (e.g. looking out for logistics, planning the workshop schedules, NGT, etc) and found that they have worked out well, especially because they helped in anticipating problems before the workshops and keeping the facilitator on track during the meetings.

Table 5 illustrates one of the scripts developed for the second workshop in the BG project. After building the causal diagram in the first session, we did not want to start the conceptualization of the stocks and flows from scratch. Also, we needed to speed up the process of defining the reference modes and collecting information to describe the observed patterns of behavior. At the same time, we aimed for listing preliminary policies to be run in the third workshop.

Table 5. Script for the second workshop of the Baixo Guadiana process.

1. Recap project objectives and present goals for the second workshop *2. Present a summary of the results from the first workshop and explain the causal loop diagram* *3. Problem articulation (Sterman, 2000):* *3.1. For each loop of the causal diagram ask for the variables lying at the heart of the problem. List variables by sector in flipcharts.* *3.2. Define time horizon – how far in the future and how far back in the past lie the roots of the problems?* *3.3. What is the historical behavior of the identified variables and concepts? What might their behavior be in the future? Draw reference modes in flipcharts.* *4. What possible information sources could be consulted to describe the reference behavior modes? Take note on the flipcharts, close to the variables list.*	*5. Define a preliminary policy for the problem, including strategic objectives, targets, measures and instruments. Use flipcharts to write down participant's suggestions. This list will be iterated in the third workshop.* *6. Explain again in more detail the fundaments of the system dynamics (SD) methodology - SD building blocks. Show examples of stock-and-flow dynamics (e.g. bathtub dynamics). Distinguish between material and information flows.* *7. Formulate dynamic hypothesis (Sterman, 2000). Use the list of variables previously elicited and listed on the flipcharts. Repeat procedure for all sectors. End by highlighting feedback loops.* *8. End session with prospects for the final workshop and organize individual meetings to collect information to formalize the model relationships.*

In the MM scoping project developed in the Ria Formosa in 1998 (cf. Videira et al., 2004a) the use of workbooks in-between sessions was not tested. In the presented cases we have distributed workbooks in every workshop session. We hypothesized that workbooks would help in reporting back to participants; provide them with background information to follow the process; and consulting stakeholders on specific changes that needed to be made to the model's structure. In our view, these tools work well in creating a "memory" of the sessions (especially important in the cases when a long period elapses between two workshops), keeping absent participants on track of developments and providing detailed explanations of the changes made to the model in-between sessions. These assumptions were confirmed by the modeling team during each project and also by the participants who declared at the end that the workbooks had been useful (all BG participants agreed whereas 93% of the RF actors have valued the aid provided by the workbooks).

Learning loop 4 - Information used and quality assurance

What did previous experience teach us? What did we want to explore? And how?

Sustainability issues call for an integration of information about economic, environmental, and social factors in decision-making (Kelly, 1998b). Conventional decision-making processes have emphasized the need for "hard facts", validated by experts and the scientific peer community. On the other hand, deliberative decision-making rests on a "post-normal" scientific paradigm in which an "extended peer community" becomes effective participant in the use of science for decisions (Funtowicz and Ravetz, 1990). This extended community then contributes to the co-production of socially robust knowledge, one that is fit for the purpose of the process, which cannot be described in limited terms as featuring scientific quality but must be fit for the context and relevant to the implicated actors (Corral Quintana, 2000; Guimarães Pereira, 2002).

Under this perspective, the issue of quality assurance of the information and methods deployed in a participatory modeling process has been somewhat overlooked. To this extent, we have used a protocol for quality assurance developed specifically for the BG case within the research activities of the ADVISOR project.

What were the results? What did we learn?

The BG protocol for quality assurance (Guimarães Pereira and Corral Quintana, 2004) was divided into six sections: framing of the process, social engagement, research group, research procedures undertaken, background information and communication of information. In the early stages of the BG case, the protocol provided normative guidance for the management of information in the participatory process. At the follow-up stage, some sections of the protocol were included in the BG questionnaire to evaluate the quality of information used during the process (Table 6).

Table 6. Selected results from the Baixo Guadiana Quality Assurance Protocol.

Criteria/Question	Results
Intelligibility of information/ The information used in the BG process complied with the target audience?	*Yes, it was balanced*: 82% *For academic experts only*: 0% *Cryptic – selected users only*: 18% *Impossible to understand*: 0%
Completeness/ How would you rate the information used?	*Fully accomplished in view of requirements*: 64% *There are information gaps*: 36% *There are too many gaps*: 0% *Not comply with requiments*: 0%
Transparency/ Was information presented in a transparent manner?	*Yes, sources of information were stated*: 55% *Only the methods used were stated*: 45% *No information on sources and methods*: 0%
Fitness for purpose/ Were the developed models relevant for the objectives of the project?	*Very relevant:* 36% *Relevant:* 36% *Sufficient:* 28% *Not very relevant:* 0% *Irrelevant:* 0%
Extend peer acceptance/ How would you rate the modeling team legitimacy and experience?	*Total:* 36% *High*: 55% *Medium*: 9% *Low*: 0% *None*: 0%

More details on the application of the quality assurance protocol to the BG case may be found in Videira et al. (2004b). This protocol proved to be useful in revealing some important criteria that had not been assessed in the RF project. The latter focused mainly on the assessment of the participants' perceptions about the "completeness" of the information used in the model (18% indicated that the information was complete, 68% said there are a few information gaps and 14% stated that there were too many gaps). With respect to the inclusion of information on the relevant sides of the problem in the RF model, the average level of agreement obtained was 4.1.

Learning loop 5 – Evaluating effectiveness of participatory modeling processes

What did previous experience teach us? What did we want to explore? And how?

Rouwette et al. (2002) performed a meta analysis of findings of 107 group modeling interventions which have used system dynamics. According to these authors, the assessment of the effectiveness should become more rigorous and standardized to allow for institutional learning within the system dynamics community. The evaluation of outcomes is proposed at four levels: individual, group, organization and method. The types of measurements considered were interviews, observations and questionnaires. In the 5 MM projects presented by van den Belt (2004), the evaluation of success was based on pre-test and post-test measurements in two cases, and in observations for the remaining projects. It was concluded that the latter evaluations were weaker on depth, structure and perspective whereas in the former cases it was possible to draw conclusions regarding the impact of the interventions (e.g. with respect to insight, ownership, communication, learning, consensus and commitment).

As previously stated, we have used pre-test and post-test questionnaires in the BG and RF cases, complemented with the observations made by the modeling team during the workshops. We report on the outcomes of the BG and RF processes within the lines suggested by Rouwette et al. (2002).

What were the results? What did we learn?

<u>Outcomes at the individual level</u>

a) Reaction

From the preliminary interviews it was possible to assess the participant's experience with system dynamics modeling and participatory processes. In the RF, 17% of the interviewees revealed that they have participated before in group modeling workshops, namely the first scoping exercise, and 14% declared to know system dynamics software, although they do not use it regularly. In the BG, 28% of stakeholders had experience with participatory processes and 14% have been introduced to Stella/Powersim programs, although they also do not use it very often. Even though the majority of stakeholders had no contact with system dynamics and participatory modeling their overall reaction to the process was very positive (Figure 6).

We have also used open questions to evaluate the reaction of participants on the best and worst things about the participatory modeling processes. In the BG, participants mentioned that the most negative aspect was "the decreasing level of participation throughout the process". In the RF, the reactions were more diversified including comments such as "the fact that the process did not have institutional support from the national administration", "not having more personal time to invest in the process", "the time elapsing between workshops" and again "the absence of some representatives in the last sessions". There is a weak correlation between this criticism and the results presented on Figure 6. In fact, some stakeholders who have mentioned a few negative aspects then responded positively to recommending the process to others and participating again in a similar event. Stakeholders who have answered "maybe" always added that it "depends on the objective".

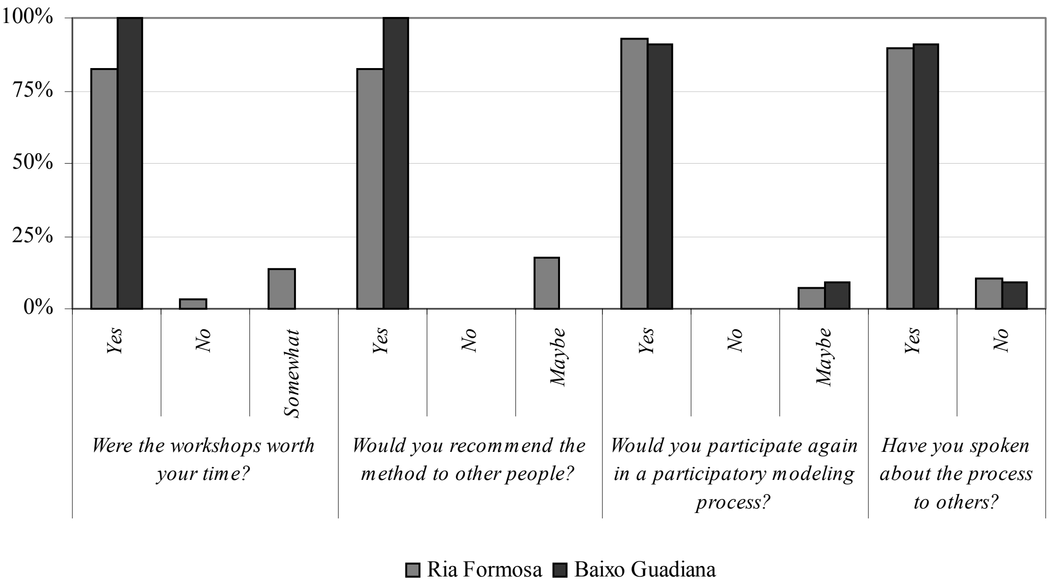


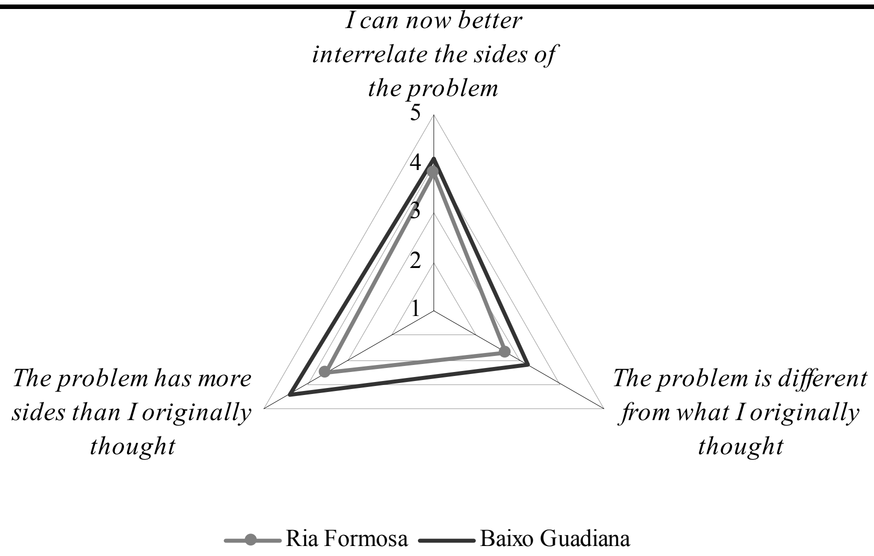
Figure 6. Participants' reaction to the participatory modeling processes.

With respect to the most positive aspects, RF stakeholders mentioned that these included "the knowledge and data gathered", "having people speaking at the same level, with no institutional hierarchies", "the openness of discussions", "the diversity of representation and involvement of so many stakeholders", "great interaction and good conduction of the process", "the development of a simulation tool", "learning about system dynamics" and a "better understanding of feedback processes". Participants of the BG workshops have found great value in "the innovative and integrative character of the intervention", "the overall interest of the results", "the possibility to have constructive dialogues with others", "the construction of a model which has potential to help decision-making processes" and the "construction of an integrated vision of the problems by means of the causal diagram".

b) Insight

In the analyses of past participatory modeling interventions, the increase in insight appears to be the most positive outcome (Rouwette et al., 2002, Stave, 2002; van den Belt, 2004). As stressed by Sterman (2000) while discussing the pitfalls of virtual worlds, "to learn participants must become modelers" (p.36). To this extent, in the design of the case studies we tried to bring group modeling tasks to the forefront of deliberation, minimizing to the extent possible the changes made to the models in-between meetings. Whenever significant changes in the structure were necessary to run the models, we informed participants through debriefings or workbooks. As the RF sessions progressed, we have observed enthusiasm and increase in the ability of participants in expressing their thoughts with stocks and flows. Less so in the BG, where participants were not so involved in the development of a formal model.

Figure 7 presents some evidence of increase in insight about the problems addressed in both projects. With respect to realizing more sides to the problem and revealing an increase in the ability to interrelate them, the RF and BG groups scored above neutral. It is also observed that on average, the BG process allowed for revealing more sides to the problem. On the other hand, in the RF case, participants seemed to have already a clear grasp of the problematic issues at stake.



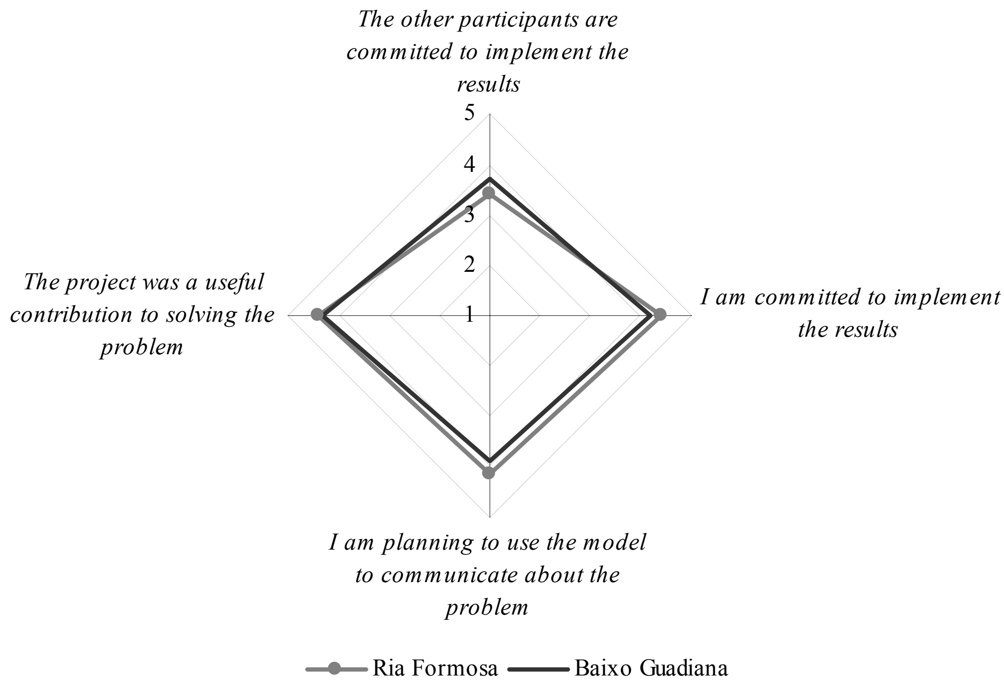
Key: 1-strongly disagree, 2-disagree, 3- agree nor disagree, 4- agree, 5- strongly agree

Figure 7. Measurements of an increase in insight through the modeling processes.

We also asked directly to participants what they had learned. Actors from the RF group revealed they had learned “to appreciate the integration of problems before taking decisions”, “about the interrelationships between some economic activities and their behavior”, “about park management”, “about modeling”, and to “integrate expert with lay persons knowledge”. The BG participants commented that the exchange of ideas generated “learning about the river basin”, “about the complexity of problems” and “raised awareness about the need to involve the interest parties in management of the area”.

c) Commitment

Previous assessments have shown that a participatory modeling project creates a positive influence on commitment towards the results. This was verified in 31 of the projects reviewed by Rouwette et al. (2002) and 2 mediated modeling projects described by van den Belt (2004). The RF and BG cases also indicate high levels of commitment (Figure 8). It is interesting to observe that in both interviewed groups, participants were somewhat suspicious of each other’s commitment towards results and believed more in their personal commitment. This fact is also related with the lower levels of consensus on future action that were achieved in the two projects, as discussed in the following section.



Key: 1-strongly disagree, 2-disagree, 3- agree nor disagree, 4- agree, 5- strongly agree

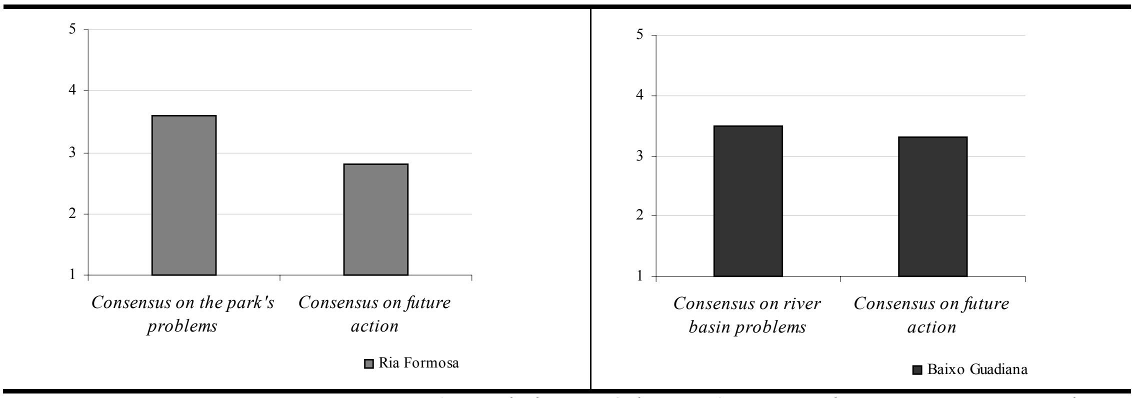
Figure 8. Commitment towards implementation of results.

Outcomes at the group level

Communication, shared language and consensus

With respect to consensus, Figure 9 illustrates the assessment of two domains which were implicit addressed – consensus on problems and consensus on policies (van den Belt, 2004). The level of consensus achieved was not strong, since according to the classification used by van den Belt (2004) that would have required for all participants to be involved in the process. Nevertheless, both groups scored above neutral (except in "future action" case for RF) and higher on problem consensus than consensus on future action. We argue that the policies and scenarios analyzed in the participatory processes needed further discussion among the group. It is suggested to dedicate more workshop hours to the policy analysis stage in future projects.

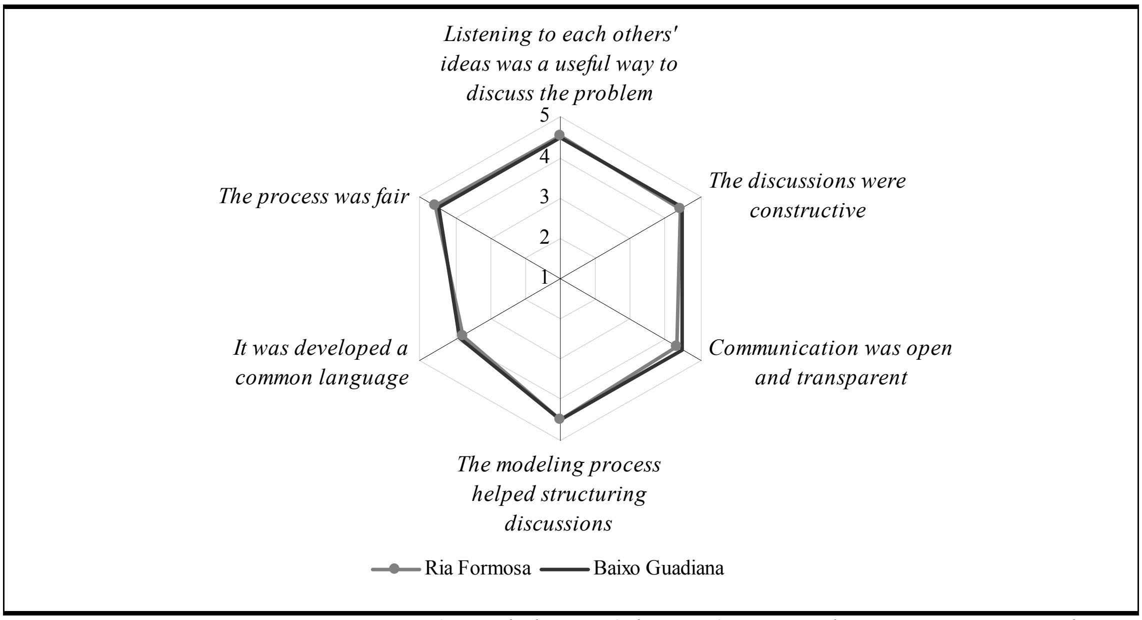
In the BG case we also asked about participants' perceptions on problem consensus and future action during the preliminary interviews. The average scores were 2.4 and 2.8, respectively. Even if the mismatch in the pre and post-interviewed groups does not allow for stronger conclusions, this indicates that the process fostered some increase in consensus, in both domains.



Key: 1-strongly disagree, 2-disagree, 3- agree nor disagree, 4- agree, 5- strongly agree

Figure 9. Perceived level of consensus.

The RF and BG projects scored almost identical results with respect to the increase in the quality of communication and the development of a shared language among participants. As depicted in Figure 10, most participants agreed (or strongly agreed) that listening to each other's ideas was a useful way to discuss the problems, discussions were constructive and developed in a transparent and open fashion, participatory events helped in structuring the discussions and the process was fair by giving an opportunity for all interested parties to intervene. The lowest average score in this category was concerned with the development of a shared language. Although it still ranked above neutral, fewer participants agreed that a common language was developed.



Key: 1-strongly disagree, 2-disagree, 3- agree nor disagree, 4- agree, 5- strongly agree

Figure 10. Communication and shared language.

<u>Outcomes at the organizational level</u>

Since the RF and BG processes were research oriented and initiated by the modeling team, accountability claims towards participant organizations are more relaxed when compared to projects initiated by client organizations. Nevertheless, we argue that if a modeling project succeeds in changing the mental models of decision-makers, system changes could be expected even if the participatory process was not initiated by client institutions. Furthermore, the positive outcomes observed at the individual and group level may steer change if committed participants manage to transfer the insights gained to their organizations.

Arguably, the most significant system change that could be expected in the RF case was the development of a management plan for the protected area, supported by the lessons from the participatory modeling project. However, park managers have informed that since management plans are not compulsory by law they will need to wait for institutional/financial support at the national administrative level to pursue this goal. Nevertheless, managers also added that they would propose to extent the annual plan of activities to a longer period to account for long-term effects of management measures, which gives some clues to follow-up. On the other hand, the results from the BG process have been recently reported to the European Commission, who is interested in providing guidelines to the river basin authorities regarding the implementation of the participatory elements of the Water Framework Directive. At the case study level, no evidence of outcomes at the organizational level has been observed yet. Again some clues for follow-up have been suggested by the participants, namely the possibility to create an inter-organizational platform to promote participatory management of the Baixo Guadiana.

<u>Outcomes with regard to method</u>

In order to promote further use of modeling, van den Belt (2004) suggests the development of tutorial sessions at the follow-up stage of a mediated modeling process, to train participants in using the mediated model. So far, we have not conducted such tutorial workshops in the RF and the BG, although we are still pursuing this goal.

To evaluate outcomes with regard to method, group modeling interventions should also be compared with other tools in terms of their efficiency in tackling similar problems (Rouwette et al., 2002). This is a crucial task to facilitate the positioning of participatory modeling in relation to other methods conducive to the strong participatory approach to sustainability presented in section 1. However, examples of integrated research on this issue are still limited.

Kallis et al. (2005) have compared the BG case study described here with two other deliberative experiments developed in the ADVISOR project. It was concluded that participatory modeling and scenario workshops performed well at the scoping stage of river basin planning processes, by promoting learning and educating participants. Nevertheless, these tools seemed to be less well positioned than social multicriteria analysis to resolve conflicts and rank alternatives. Raushmeyer and Risse (2005) compared MM with consensus conferences, citizens' juries and cooperative discourse. MM appeared to perform better in terms of criteria such as learning and elicitation of information from stakeholders and worse with respect to representation and coping with uncertainty.

Finally, it should be stressed that further research is also needed on the complementarity between distinctive participatory tools. For instance, Antunes et al. (2005) discuss possible avenues to the integration of mediated modeling and multicriteria assessment in the framework of sustainable development issues. Kallis et al. (2004) propose the combination of participatory modeling with other methods in designing deliberative decision-making processes for sustainable river basin governance.

5. The science and art of participatory modeling

For some time now there have been calls to develop research on group modeling interventions mindful of the need to add more science to the craft (Andersen et al., 1997). Allowing for replication and accumulation of results is particularly important in participatory modeling for sustainability, since the number of applications is still limited.

Building on the previous experiences in group model-building and mediated modeling, we have developed two case studies to investigate the role of participatory modeling in contributing to environmental planning and management in protected areas and river basins. In our research design we developed synergies between the two approaches and tested a few hypotheses on the improvements to the group-model interventions. We have focused on the lessons drawn in addressing the level of stakeholder collaboration in model development, the issues of legitimacy of representation, the importance of preparatory activities, the information quality assurance and the evaluation of the outcomes. Both projects performed well with respect to the outcomes at individual and group level, providing a platform for structured deliberation at the problem scoping and alternative generation stages of the planning processes. This leaves a positive indication with respect to the value of participatory modeling in achieving strong participation goals such as integration and co-production of knowledge, appreciating different values and increased commitment. We also left some clues for future research to address the integration of group modeling interventions with other participatory methods.

Science differs from art because it looks for generalization instead of ad hoc solutions. Nevertheless, science and art share the sense of innovation and the underlying motive to astonish and discover (Dibbets, 2002). Despite the growing science, participatory modeling also needs the art in observation and intuition to elicit knowledge from the stakeholder group so that the desired behavior arises from the structure. As van Gogh wrote " …I always observe nature…I don't invent the whole painting. On the contrary, I find it ready in nature. I just need to extract it" (Chipp, 1984, p. 37). He added "I cannot work without a model…because when it comes to form, I'm afraid to distance myself from what is real".

Acknowledgments

The authors would like to acknowledge the support of the Portuguese National Foundation for Science and Technology (FCT) to the research project PNAT/1999/GES/15010 and BD/13771/97; and the European Commission EESD-RTD program to the ADVISOR project (EVK1-CT-2000-00074). They are also appreciative of the collaboration of Isabel Pires, Sofia Gamito, Anabela Resende, Idália Sebastião, Daniel Borrego, Gonçalo Lobo, Ângela G. Pereira and Serafin C. Quintana in the development of the case studies.

References

Akkermans, H., Vennix, J. 1997. Clients' opinions on group model-building: an exploratory study. *System Dynamics Review*, **13** (1): 3–31.

Andersen, D., Richardson, G. 1997 Scripts for Group Model Building. *System Dynamics Review*, **13** (2), 107-129.

Andersen, D., Richardson, G. 1997. Group model building: adding more science to the craft. *System Dynamics Review*, **13** (2): 187-201.

Andersen, D., Richardson, G. and Vennix, J. (1997) Group model building: adding more science to the craft. System Dynamics Review, 13 (2), 187-201

Antunes, P. Santos, R., Videira, N. 2005. Participatory decision making for sustainable development - the use of mediated modelling techniques. *Land Use Policy* (in press).

Bandura, A. 1977. *Social Learning Theory*. Prentice-Hall: London.

Bear, D. 1994. *Public Participation in Environmental Decisionmaking*. American Bar Association Standing Committee on Environmental Law: Washington, DC.

Beierle, T.; Cayford, J. 2002. *Democracy in practice. Public Participation in Environmental Decisions*. Resources for the Future: Washington DC.

Boumans, R., Costanza, R., Farley, F., Wilson, M., Portela, R., Rotmans, J., Villa, F., Grasso, M. 2002. Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. *Ecological Economics*, **41**: 529-560.

Cavana, R. and Ford, A. 2004. Environmental and resource systems: Editor's introduction*.* *System Dynamics Review*, **20** (2): 89-98.

Chipp, H. 1984. *Theories of Modern Art*. University of California Press: Berkeley.

Corral Quintana, S. 2000. *Una Metodología Integrada de Exploración de los Procesos de Elaboración de Politicas Públicas*. Universidad de La Laguna, Tenerife. EC - Joint Research Centre: EUR 19724 ES.

Costanza, R. 1991. Assuring sustainability of ecological economic systems. In: Costanza, R. (ed). *Ecological Economics: The science and management of sustainability*. Columbia University Press: New York.

Costanza, R. 1999. The ecological, economic, and social importance of the oceans. *Ecological Economics*, **31**: 199-213

Costanza, R. and Jorgensen, S. 2002. *Understanding and Solving Environmental Problems in the 21st Century, Toward a new, integrated hard problem science*. Elsevier Science Ltd: Oxford.

Costanza, R. and Ruth, M. 1998. Using dynamic modeling to scope environmental problems and build consensus. *Environmental Management*, **22** (2): 183-195.

Costanza, R., Daly, H., Bartholomeuw, J. 1991. Goals, agenda, and policy recommendations for ecological economics. In: Costanza, R. (ed). *Ecological Economics: The science and management of sustainability*. Columbia University Press: New York.

Deaton, M. and Winebrake, J. 1999. *Dynamic Modeling of Environmental Systems*. Springer-Verlag: New York.

Dibbets, J. 2002. Interactions between science and art. *Cardiovascular Research*, **56**: 330-331.

Eppink, F., van den Bergh, J., Rietveld, P. 2004. Modelling biodiversity and land use: urban growth, agriculture and nature in a wetland area. *Ecological Economics*, **51**: 201-216.

Fiddaman, T. 2002. Exploring policy options with a behavioral climate-economy model. *System Dynamics Review*, **18** (2): 243-267.

Ford, A. 1996. Testing the snake river explorer. *System Dynamics Review*, **12** (4):305-329.

Ford, A. 1997. System Dynamics and the Electric Power Industry. *System Dynamics Review*, **13** (1):57-85.

Ford, A. 1999. *Modeling the Environment*. Island Press: Washington, DC.

Forrester, J., 1971. World Dynamics. MIT Press: Cambridge, MA.

Funtowicz S, and Ravetz J.R. 1990. *Uncertainty and Quality in Science for Policy*, Kluwer: Dordrecht.

Guimarães Pereira, A. 2003. Quality of Information in River Basin Governance, Review of Case Studies: Information Vertex, Report Prepared for the ADVISOR Project.

Hannon, B., M. Ruth. 1994. Dynamic Modeling, Springer-Verlag: New York.

Hare, M., Letcher, R.A., Jakeman, A.J. 2003. Participatory Modelling in Natural Resource Management: A Comparison of Four Case Studies. *Integrated Assessment*, **4**: 62-72.

Hodgson, A. M. 1994. Hexagons for system thinking. In: J.D.W. Morecroft & J.D.Sterman (ed). *Modeling for Learning Organizations*. Productivity Press: Portland.

Holmes, T., Scoones, I. 2000. Participatory environmental policy processes: experiences from north and south. *IDS Working Paper 113*, Institute of Development Studies.

IAP2. 2000. Public participation spectrum. 17 July 2002. Available at: http://www.iap2.org. International Association for Public Participation.

Jones, A., Seville, D., Meadows, D. 2002. Resource sustainability in commodity systems: the sawmill industry in the Northern Forest. *System Dynamics Review*, **18** (2): 171-204.

Kallis G., Videira, N., Antunes, P., Guimarães Pereira, Â., Spash, C.L., Coccossis, H., Corral Quintana, S., del Moral, L., Hatzilacou, D., Lobo, G., Mexa, A., Paneque, P., Pedregal, B., Santos, R. 2005. Participatory methods for water resources planning. *Environment and Planning C: Government and Policy* (in press).

Kallis, G., Videira, N., Antunes, P., Santos, R. (ed). 2004. Integrated Deliberative Decision Processes for Water Resources Planning and Management – A guidance document. Report of the ADVISOR project. Ecoman Center: Lisbon.

Kaner, S. 1996. Facilitator's guide to participatory decision-making. New Society Publishers: Gabriola Island.

Kapoor, I. 2001. Towards Participatory Environmental Management? *Journal of Environmental Management*, **63**(3): 269 - 279.

Kelly, K. 1998a. The effects of a group model building intervention on information choices for sustainable development decision making. Proceedings of the System Dynamics Conference 1998, Quebec, Canada.

Kelly, K. 1998a. The effects of a group model building intervention on information choices for sustainable development decision making. Proceedings of the System Dynamics Conference 1998, Quebec, Canada.

Kelly, K. 1998b. A systems approach to identifying decisive information for sustainable development. *European Journal of Operational Research*, **109** (2): 452-464.

Low, B., Costanza, R., Ostrom, E., Wilson, J., Simon, C. 1999. Human–ecosystem interactions: a dynamic integrated model. *Ecological Economics*, **31**: 227-242.

Meadows, D. 1998. *Indicators and information systems for sustainable development – a Report to the Balaton Group*. Sustainability Institute: Hartland.

Meadows, D. H., Meadows, D.L. and Randers, J. 1992. *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*. Chelsea Green Publishing Company: Post Mills:

Meadows, D. H., Meadows, D.L., Randers, J., Behrens. 1972. *The Limits to Growth*. Universe Books: New York.
Meppem, T. Gill, R. 1998. Planning for sustainability as a learning concept. *Ecological Economics*, **26**: 121–137.
Moxnes, E. 2000. Not only the tragedy of the commons: misperceptions of feedback and policies for sustainable development. *System Dynamics Review*, **16** (4): 325-348.
O'Neill J. 2001. Representing people, representing nature, representing the world. *Environment and Planning C: Government and Policy*, **19**(4) 483-500.
Petts, J. 2003. Barriers to deliberative participation in EIA: learning from waste policies, plans and projects. *Journal of Environmental Assessment Policy and Management*, **5** (3): 269-293.
Prugh, T., Costanza, R., Daly, H. 2000. *The local politics of global sustainability.*: Island Press: Washington, DC.
PSCD – The President's Council on Sustainable Development. 1996. *Sustainable America, A new consensus*. US Government Printing Office: Washington DC.
Randers, J. 2000. From limits to growth to sustainable development or SD (sustainable development) in a SD (system dynamics) perspective. *System Dynamics Review*, **16** (3): 213-224.
Rauschmayer, F., Risse, N. 2005. A framework for the selection of participatory approaches for SEA. *Environmental Impact Assessment Review* (In press).
Richardson, G. and Andersen, D. 1995. Teamwork in group model-building. *System Dynamics Review*, **11** (2): 113-137.
Rouwette, E., Vennix, J. and Mullekom, T. 2002. Group model building effectiveness: a review of assessment studies. *System Dynamics Review*, **18** (1): 5-45.
Saeed, K. 1998. Sustainable trade relations in a global economy. *System Dynamics Review*, **14** (2-3), 107-128.
Stave, K. 2002. Using system dynamics to improve public participation in environmental decisions. *System Dynamics Review*, **18** (2): 139-167.
Stave, K. 2003. A system dynamics model to facilitatie public understanding of water management options in Las Vegas, Nevada. *Journal of Environmental Management*, **67**: 303-313.
Sterman, J. 2002. All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review*, **18** (4): 501-531.
Sterman, J. and Sweeney. L. 2002. Cloudy skies: assessing public understanding of global warming. *System Dynamics Review*, **18** (2): 207-240.
Sterman, J.D. 2000. *Business Dynamics - Systems Thinking and Modeling for a Complex World*. McGraw-Hill: Boston
Sudhir, V., Srinivasan, G., Muraleedharan, V.R. 1997. Planning for sustainable solid waste management in urban India. *System Dynamics Review*, **13** (3): 223-246.
UNCED. 1992. *Rio Declaration on Environment and Development*. The United Nations Conference on Environment and Development, Rio de Janeiro 3-14 June 1992.
van den Belt, M. 2004. *Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building.* Island Press: Washington.
van den Belt, M., Deutsch, L., Jansson, A. 1998. *A consensus-based simulation model for management in the Patagonia coastal zone. Ecological Modelling*, **110**: 79-103.
van den Hove, S. 2000. Participatory approaches to environmental policy-making: the European Commission Climate Policy Process as a case study. *Ecological Economics*, **33**: 457-472.
Vennix, J. 1999. Group model-building: tackling messy problems. *System Dynamics Review,* **15** (4): 379-401.

Vennix, J. 1996. Group Model-Building: Facilitating Team Learning Using System Dynamics. Wiley: Chichester.

Vennix, J., Andersen, D., Richardson, G., Rohrbaugh, J. 1992. Model-building for group decision support: Issues and alternatives in knowledge elicitation. *European Journal of Operational Research*, **59**: 28-41.

Videira N, Antunes P, Santos R, Gamito S. 2003a. Participatory modelling in environmental decision-making: the Rio Formosa natural park case study. *Journal of Environmental Assessment Policy and Management*, **5**(3) 421-447.

Videira, N., Antunes, P., Santos, R., Borrego, D., Lobo, G. 2004b. Mediated Modelling to Support Public and Stakeholder Participation in Water Resources Planning and Management: The Baixo Guadiana Experience, Portugal. In: Videira, N., Kallis, G., Antunes, P., Santos, R. (eds.) Advisor Final Report. Ecoman Center: Lisbon.

Videira, N., Antunes, P., Santos, R., Borrego, D., Lobo, G. 2004b. Mediated Modelling to Support Public and Stakeholder Participation in Water Resources Planning and Management: The Baixo Guadiana Experience, Portugal. In: Kallis, G, Videira, N, Antunes, P., Santos, R. (eds.) Advisor Final Report. Ecoman Center: Lisbon.

Videira, N., Antunes, P., Santos, R., Gamito, S., van den Belt, M. 2004a. Decision Support in Coastal Zone Management in the Ria Formosa, Portugal. In: van den Belt, M. (ed). *Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building*. Island Press: Washington, DC.

Yearley, S., Cinderby, S., Forrester, J., Bailey, P., Rosen, P. 2003. Participatory Modelling and the Local Governance of the Politics of UK Air Pollution: A Three-City Case Study. *Environmental Values*, **12**: 247-262.