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Participatory modelling for sustainable development: Key issues derived from five cases of natural resource and disaster risk management

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ABSTRACT

Stakeholder participation is considered a key principle for sustainable development in the context of natural resource and disaster risk management. Participatory modelling (PM) is an interactive and iterative process in which stakeholder involvement is supported by modelling and communication tools. Planning and decision-making for sustainable development (SD)integrate three *substantive* dimensions − social, ecological and economic. The *procedural* dimension of SD, however, is equally important, and here we see great potential for PM. In this study, we evaluate five PM research projects against criteria for the *procedural* dimension of SD. This provides a basis for identifying key issues and needs for further research into PM for SD. While the cases show great potential, especially for supporting knowledge integration, learning and transparent handling of values and perspectives, they indicate a particular need to develop PM in respect of organizational integration. This issue is closely connected to the possibility of effectively implementing PM in practice.

1. Introduction

In the last few decades, policy analysis studies have identified the importance of stakeholder participation of relevant actors to ensure sustainable natural resource and disaster risk management (Biswas, 2005; White et al., 2010; Vojinovic and Abbott, 2012; Newig et al., 2014). New policy documents and legal frameworks in the area underline these requirements of participatory governance (e.g. Aarhus convention, EU Water Framework directive, Environmental Impact assessment Directive).

Planning and decision-making to ensure SD imply integration of the three pillars − social, ecological and economic (Robinson, 2004; Ginson, 2006) − the *substantive* dimensions of SD (Robinson, 2004). In order to achieve such integration, however, the *procedural* dimension of SD is equally important to consider (*ibid.*). A sustainable procedure can be described as a political conversation[1] of desirable futures, informed by scientific knowledge from a broad range of effectively integrated disciplines (Robinson, 2003; McMichael et al., 2003; Clarke and Dickson, 2003), as well as by the knowledge and perspectives of those actors variously affected by the plan or decision in hand (Ostrom, 2009; Vaidya and Mayer, 2014).

Against this background, we see great potential for Participatory Modelling (PM) − an interactive and iterative process in which participatory planning is supported by computer-aided modelling and other types of communication tools. One of the main reasons for its potential is that PM supports the integration of scientific and contextual knowledge by developing a joint knowledge base which leads to social learning in a pre-defined process of interaction between scientists and/or civil servants and local stakeholders (Pahl-Wostl et al., 2007). It is also argued that these types of efforts are able to bridge the science-policy gap, if framed systematically (Smajgl et al., 2013). Another important and interlinked argument is that PM may help to manage complex and wicked problems (Davies et al., 2015). PM assists joint decision-making by opening up and defining different perspectives and solutions that may include compensation for those negatively affected. PM also involves a thinking process which takes both the dynamics of scientific knowledge development and the political decision-process into consideration; this can increase trust in and the legitimacy of the process (Becu et al., 2008). Furthermore, PM supports the development of a local participatory management structure, and by safeguarding important democratic values it may improve the long-term handling of our natural resources (Etienne, 2014).

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[1] By political conversation we mean that the conversation involves consideration of values and value trade-offs.

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Table 1
Outline of the theoretical framework used. For a complete description, see Hedelin (2007, 2015a, 2016).

Key sustainability principle	Generating theme		Criteria Sustainable planning processes have to include, support or promote …
Integration	…across disciplines	A	integration of knowledge from all relevant disciplines.
		B	handling of different views of knowledge (e.g. positivist, relativist).
		C	handling of different kinds of uncertainty.
	…across values	D	identification of the most relevant values in relation to the current issue.
		E	rational argumentation: relating identified values to alternative choices in the planning process.
Participation	…contributing to the process	F	inclusion of knowledge owned by relevant actors.
		G	inclusion of the ideological orientations represented by relevant actors.
		H	participation in the most critical phase(s) of the process.
	…generating commitment, legitimacy or acceptance	I	a procedure for defining the actors that should be involved.
		J	handling of power asymmetries.
		K	Procedures that ensure that ideological orientations are not suppressed (for consensus-based approaches).
		L	stakeholder learning.
Integration	…across organizations	M	organizational learning.
		N	handling of the formal planning context.
		O	handling of incentives, including resources and efficiency (removing of thresholds).
		P	handling of human aspects coordination (trust, engagement, conflict management).

The aim of this study is to contribute to a baseline for research on how PM can be used as a tool for sustainable processes in the context of wicked problems such as natural resource and disaster risk management. We apply a theoretical framework for sustainable development as process (Hedelin, 2007, 2015a, 2016) to five large PM projects in order to present a theory-based and in-depth synthesis and evaluation of the cases, and to indicate key functions and issues for PM as a tool for sustainable processes.

Using models in a stakeholder process has been given different names, including 'mediated modeling' (Van den Belt, 2004), 'companion modeling' (e.g. Barreteau, 2003), 'group model building' (Andersen and Richardson, 1997), "collaborative modelling" (John et al., 2014; Niswonger et al., 2014) as well as the more generic 'participatory modeling' (Voinov and Bousquet, 2010). The body of scientific literature in this field has grown steadily during the last decade and now includes different levels of ambitions of model-tool complexity and of stakeholder involvement (Seidl, 2015). These efforts are in what can be named participatory research, in relation to which Cornwall and Jewkes already in 1995 pointed out the diverse interpretations of the concept of participation and requested greater stringency in qualifying the meaning of participatory research (Cornwall and Jewkes, 1995). Inspired by Probst and Hagmann (2003) and Biggs (1989), Barreteau et al. (2010) have categorized these efforts into four different levels of participation, namely collegiate, collaborative, consultative and contractual participation, during which control over the research process shifts from local people to scientists.

PM, as we define it here − an interactive and iterative process in which a participatory planning process is supported by computer-aided modelling and other types of communication tools − is in line with all the approaches mentioned above. Importantly, PM applies here not only to joint development and usage of computer based models representing different aspects of the physical/natural system, but also to the engagement of stakeholders[2] and other actors in a decision-making process. Such a process can include, for example, base-line analysis, goal definition, simulation, scenario analysis, designing and testing measures, and the selection of alternatives (cf. Jonsson et al., 2005; Andersson et al., 2010; Alkan Olsson et al., 2011; Evers et al., 2012a, 2012b; Jonoski and Evers, 2013).

2. Method and theory

The authors' collective experiences from five large PM research projects (described below) provide the empirical basis for this analysis (Jonsson et al., 2005; Alkan Olsson et al., 2011; Jonsson and Wilk, 2014; Wilk and Jonsson, 2013; Evers et al., 2012a, 2012b). This in-depth approach and the theoretical perspective applied (described below) facilitate a reflective, critical research approach and permit the systematic inclusion of experiences that have not previously been reported from the individual case studies.

The cases are analyzed using the sustainable procedure framework (SPF),[3] developed and applied in the context of natural resource and disaster risk management. There are a number of participatory frameworks and best practice guidelines for participation and PM in literature, such as Hassenforder et al. (2015), Perez et al. (2014), Smajgl and Ward (2013), Korfmacher (2001) and Barreteau et al. (2010). Compared to these, the SPF allows for (simultaneously):

- studying PM explicitly in relation to the concept of SD,
- a focus on procedure (compared to output, e.g. a management plan, an implemented measure),[4]
- a theory-based analysis,
- a critical perspective (due to the deductive and normative character of the SPF),
- a governance perspective on PM (due to inclusion of issues such as representation and organizational integration).

The SPF is intended for the development and assessment of natural resource and disaster risk management procedures at national, regional and local levels and typically in river basin management and municipal land use planning. See Table 1 for an outline.

The framework has been developed as a response to the need for establishing ways to explicitly and systematically relate practical planning and decision-making procedures to the concept of SD. The difficulty of relating a specific practice to the abstract and theoretical concept of SD is well recognized (Robinson, 2004; Chesson, 2013). The approach uses two SD-principles – Integration and Participation – as a first step to implementation. These are both well-established principles of SD procedure and by far the most cited in both natural resource and disaster management (see for example Gregersen et al., 2007; Campbell and Sayer, 2003; Henriksen et al., 2009; Sawhney et al., 2007). Based on these principles, a set of criteria has been derived that describes the constituents needed for an integrative and participatory procedure.

[2] Stakeholders are those who are affected by a planning or decision-making process, and can include lay people, representatives for different types of organizations, as well as decision-makers and civil servants.

[3] For a detailed explanation of the SPF and how it is derived, see Hedelin (2007, 2015a, 2016).

[4] The process and its outputs are strongly dependent, and the value and function of the resulting plan or measure depends on the quality of the process.

Table 2
Overview of PM case studies.

Case	DIANE	WPI+	VASTRA	DEMO	SEAMLESS
Period	2008–2011	2006–2008	2001–2005	2005–2007	2005–2009
Financed by	FP6	Sida/Sarec	MISTRA	FORMAS	FP6*
Problem area	Flood risk management	Integrated water management	Eutrophication	Eutrophication	Agricultural-environmental policy analysis
Country	UK/Germany	India	Sweden	Sweden	European Union
Geographical scale	River basin (9,1 km^2 and 578 km^2)	Local	River basin (1900 km^2)	River basin (475 km^2)	European Union (Nuts 2 and 3)
Administrative scale/s	Local and regional scale: 1 community / 2 federal states	Local scale: one village of 100 hhs	Regional scale: 13 municipalities, Skane Region	Regional scale: 3 municipalities, 2 county administrative boards	Multiple scales: European Union National Regional

Abbreviations: See the section below for explanation of the case names. Funders: FP6 is the EU's 6th Framework Programme for research and technological development, Sida/Sarec is the Department for Research Cooperation of the Swedish International Development Cooperation Agency, MISTRA is the Swedish Foundation for Strategic Environmental Research, FORMAS is the Swedish Research Council for Sustainable Development.

The framework establishes a structure for interdisciplinary knowledge integration, systematized in relation to the concept of sustainable development via so called sustainable development principles (see Table 1). Using the framework has resulted in practical recommendations for improving planning processes in relation to SD (Hedelin, 2008; Hedelin and Lindh, 2008; Hedelin 2015b).

Criteria A to E stem from the concept of integration and are much influenced by research on integrated management (Born and Sonzogni, 1995; Bellamy et al., 1999; Margerum, 1999; Sneddon et al., 2002). They are based on the idea that integration can be achieved across disciplines (A–C) and across values (D and E) (Jepson, 2001). Criteria F to L are closely linked to participation and much influenced by participatory planning and deliberative democracy (e.g. Healey, 2006; Grote and Gbikpi, 2002; Dryzek, 2000). The criteria are structured according to the main aims of participation processes – increasing the quality of decisions, and generating the necessary commitment, legitimacy or acceptance (Hemmati et al., 2002). Criteria M–P stem from the concept of integration, which, in addition to the already mentioned dimensions, needs to be achieved across organizations (Jepson, 2001). These criteria are mainly derived from research on organizational learning, multilevel governance, organizational coordination and collaborative planning (Rashman et al., 2009; Prager, 2010; Susskind et al., 2012; O'Leary and Vij, 2012; Weiss and Hughes, 2005). Criterion M concerns the need to establish learning processes that involve more persons than the ones who are directly engaged in the participatory process, such as the organizations and stakeholder groups that are represented by the persons in the process. Criterion N concerns the need to relate and adjust the process to its formal decision-making context, such as the key related legislations, authorities and ongoing planning processes. Criteria O and P concern the issue of creating the necessary incentives to participate – both in respect of more formal incentives such as authority mandates, time and money, and, in terms of social incentives such as trust and engagement.

The criteria are linked in various ways, the integration of knowledge and values (A to E) are for example highly dependent on the involvement of the respective actor's knowledge and ideological orientations (F and G).

3. The PM cases

All the cases have relatively high ambitions in relation to stakeholder involvement, but also mainly involve complex to highly complex models that had been developed and used before in an expert-only context. The participatory character of the cases can be described as consultative[5] (Barreteau et al., 2010). All projects were science driven, involving both social and natural scientists (economists, geographers, political scientists, engineers etc.). Apart from these similarities, the studied cases include an array of contexts, such as developed and developing countries, different topics (flood risk management, water resources and poverty, eutrophication and agricultural policy), different geographical scales (local, regional national and continental), and various levels of policy process integration (integration between the research project and a formal decision-making process). See Table 2 for an overview of the case characteristics.

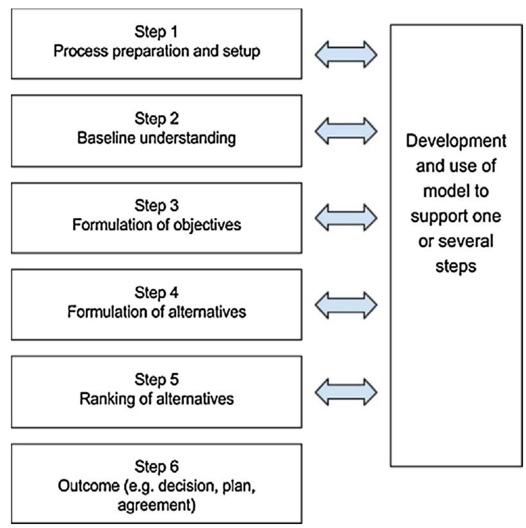

Fig. 1. Generic model of a PM process. Several of the steps involve stakeholders and several may involve models. Based on models by Evers et al. (2012a, 2012b) and Alkan Olsson et al. (2011).

The structure of the cases can be described using a generic process model, see Fig. 1. It includes six steps covering the main topics that can be handled in a PM process. A project based on PM does not necessarily include all steps, and steps can include different activities, depending on the context and issue at stake.

3.1. DEMO

The DEMO project (Participatory Catchment Modelling for Sustainable Water Management) involved farmers, owners of a private sewage system, representatives of the Federation of Swedish Farners, municipality staff, officials from regional and WFD management bodies in a catchment area in south-east Sweden. The project was locally initiated and started as a smaller pilot project, later receiving research funding. Its aim was to develop a method for participatory modelling where different models could be used as a basis for water management decisions and to improve joint

[5] Most of the key decisions are made by one actor, but emphasis is put on consultation and gathering information from other actors, especially for identifying constraints and opportunities, priority setting, and/or evaluation.

understanding of developing sustainable nutrient management including the selection of commonly agreed alternatives within the EU Water Framework Directive. Models used in the study included one model for farm-scale leaching of nitrogen, STANK (Aronsson and Torstensson, 2004), and one for phosphorus leaching, ICECREAM (Larsson et al., 2007). Outputs from these two models were fed into the catchment model HBV-NP (Andersson et al., 2005). Model set-up and output were improved by input of local knowledge; stakeholders defined local goals for water quality in the water basement and chose between management alternatives. Moreover, implementation barriers at different levels and responsible actors/agencies were identified. The process included around 50 meetings in mixed or non-mixed stakeholder groups of various sizes. The topic of the meetings approximately followed the generic process model (Steps 1–6, Fig. 1) and resulted in a locally adapted plan of measures to be taken in the targeted catchment that also identified barriers to improve the water status in the targeted water basin form the local stakeholder's perspective. The project was integrated into the policy process in the sense that ideas and difficulties were continuously discussed with people in the newly established water authorities responsible for implementing the WFD in Sweden. There was, however, no formal integration into a policy process (Alkan Olsson et al., 2011; Jonsson et al., 2011).

3.2. DIANE

The objective of the DIANE-CM project (Decentralised Integrated ANalysis and Enhancement of Awareness through Collaborative Modelling and Management of Flood Risk) was to develop and evaluate alternatives for flood risk management and to test these under different scenarios that could be used for negotiation and involved representatives from, for example, Flood Risk Management, the Fire Brigade, the Environment Agency, NGOs, as well as citizens. A PM framework was developed and tested in two case study areas in Germany and the UK. The framework consisted of all steps illustrated in Fig. 1.

The aim of the project was to increase flood resilience in urban areas through flood risk awareness rising. In order to reduce urban flood vulnerability it is crucial that stakeholders and citizens become more aware of potential flood risk and improve their capacity to handle this risk. Social learning processes were considered essential for capacity building as these provide tangible information and target-group-specific and localized knowledge. Simulation and visualization of scenarios and alternatives were important elements in this process. For this purpose, hydrological and hydrodynamic models, such as well as GIS and Google Maps were used. Opportunities for interaction were given during workshops, via a web-based collaborative platform (forum), e-mail etc. Stakeholders included representatives from the responsible authorities. The results of the agreed measures were considered in the implementation of the flood risk management plan, as a part of the implementation of the Floods Directive (Evers et al., 2012a, 2012b).

3.3. SEAMLESS

The SEAMLESS project (System for Environmental and Agricultural Modelling; Linking European Science and Society) involved farmers' organizations, food lobbyists, Director Generals (environment, agriculture end regional development) and regional authorities. The research aim of the project was to further the modelling efforts in the agro-environmental area and to develop structures for integrating models covering environmental, economic and social issues as well as different scales. The societal aim of the project was to develop an integrated assessment tool for the possible impact of new EU agri-environmental policy at EU, national and regional levels. Stakeholders at all levels were engaged in the development of the tool through a set of case studies in different countries and at different scales which focused on different agro-environmental problems. The project was integrated into the policy process in the sense that the idea and the need for this type of tool had emerged from the Commission. However, the project was a research project and as such should be seen as developing and testing a potential future process where real examples were used as a way to discuss with potential stakeholders how such a tool could work and what it should include (Van Ittersum et al., 2008). Several models were used covering different aspects and different scales of the agricultural system, e.g. CAPRI (an economic model at the market level), FSIMM (an economic model at the farm level) and APES (a biochemical model at the field level). An Open source structure was used to support integration of the models (van Ittersum et al., 2008).

3.4. VASTRA

The Rönne river dialogues in the VASTRA program (Swedish Water Management Research Program – Towards Catchment-Based Strategies for Sustainable Resource Use) had two aims: a science-based implementation of the EU Water Framework Directive (WFD) focusing on eutrophication, and, to develop a decision-support structure to reduce the leaching of nutrients from agriculture. The PM process was built around a hydrological model; HBV-NP (Arheimer et al., 2005). The PM exercises focused on methods development rather than on practical decision-making. During Step 1, the project engaged researchers, local stakeholders (farmers, representatives of municipalities, recreational interests and industry in the Rönne catchment area) and regional and local authorities organized a series of stakeholder meetings. Here, results from hydrological models including N- and P-leaching were presented to the stakeholders (Step 2) in the form of focus group discussions to collect views and perspectives on measures to reduce nitrogen leaching (Steps 3 and 4). The discussions were complemented by interviews with local farmers.

The integration into the policy process was mainly indirect as the VASTRA research was done in connection with start-up work for the implementation of the WFD in Sweden (Jonsson et al., 2005; Alkan Olsson and Berg, 2005).

3.5. WPI+

The WPI+ project (Defining a Water Poverty Index (WPI) through stakeholder participation) involved researchers, villagers, NGO workers and local government officials in Step 1. The aim was to develop a participatory method for the assessment and analysis of water resource management and poverty taking the Water Poverty Index (WPI) developed by Sullivan and Meigh, 2003; Sullivan and Meigh, 2005 as a point of departure. Thus the process focused on Step 2 by analyzing the present situation in an inclusive manner. By applying index components such as access, resources, use, management capacity and environmental values in relation to water, the WPI developed into something more forward-looking and goal-oriented than just a diagnostic index, i.e. the Water Prosperity Index, the WPI+, and thus also touched on Step 3. Within the project, interaction to determine variables and assessing them in terms of local knowledge enabled the visualization of tangible and target-group-specific information. This promoted a shared understanding of water management issues from different perspectives: men/women, landowners/agricultural laborers, villagers/government officials. By conducting 2 × 7 workshops with villagers, and in conjunction with a local NGO, the bottom-up orientation of the project was strong. Two workshops were conducted with local officials and villagers and one workshop at state level with the World Bank (Step 6). On the whole, however, the PM process was not really integrated into ongoing policy processes (Wilk and Jonsson, 2013; Jonsson and Wilk, 2014).

4. Result

This section describes how the cases address the criteria of the SPF. See Table 3 for a summary.

Table 3
Summary of results.

Criterion Sustainable planning processes should include, support or promote … [criterion]	Level of agreement between criteria and cases. I.e. indicated potential of PM as tool for SD processes	Description of how the PM cases are evaluated against the SD criteria
A integration of knowledge from all relevant disciplines.	Medium	A broad knowledge base is used in all cases together with various activities and techniques that support their integration, e.g. focused group discussions, workshops, database set-up and visualization in maps. In some cases, the use of complex models restrains the application of social scientific knowledge.
B handling of different views of knowledge	Low	No explicit strategy exists in any of the cases, however, for handling different views of knowledge.
C handling of different kinds of uncertainty.	Medium	No explicit and systematic approach for handling of uncertainties is used, but two important features support this criterion: simulated scenarios and the participatory approach as such (contributing with knowledge and questioning model results).
D identification of the most relevant values	Medium	All cases apply systematic procedures for identifying the main values of the process. The project context and the models used steer the scope of these values. The participatory approach ensures broadening of the perspective in terms of values.
E rational argumentation based on the identified values	High	Tools are generally used that alone or in combination may provide support for transparent and rational argumentation related to values, such as multi-criteria-analysis, functions for ranking of alternatives and electronic voting, indicators, Geographical Information Systems and simulation models, structured group discussions and workshops.
F inclusion of knowledge owned by relevant actors.	High	Generally, much effort is put into integrating knowledge from participating stakeholders.
G inclusion of the ideological orientations represented by relevant actors.	Medium	All cases apply well thought-out procedures for integrating actors' ideological orientation.
H participation in the most critical phase(s) of the process.	Medium	While participation is tied to different phases in the studied cases, a general and important observation is that issues of design and choice of measures (how to get there) take up more space in the processes than issues of societal development (where to go).
I procedure for defining the actors that should be involved.	Medium	The cases include more or less systematized strategies for defining whom to involve.
J handling of power asymmetries.	High	All cases use effective methods such as structuration of communication, class- and gender-separated meetings, targeted times and places of meetings, web-based communication and pocket chart voting.
K procedures that ensure that ideological orientations are not suppressed	Medium	All cases use group discussions partly to create consensus and a "common understanding" of issues, which may promote the suppression of less well-represented ideological orientations. Most of the techniques supporting J, however, support criterion K.
L stakeholder learning.	High	Stakeholder learning is a central idea of the cases and utilizes a broad range of approaches: a wide range of participating stakeholders, workshops, series of group discussions, boundary-spanning persons, visualization of scenarios and simulations in maps, modelling exercises, actor network analysis, and ranking and voting exercises.
M organizational learning.	Low	Few activities aim directly at establishing structures necessary for organizational learning to occur on a long-term basis.
N handling of the formal planning context.	Medium	Three cases indirectly consider a limited part of their formal planning context. One case is not connected to a formal planning context and does not consider this issue. Two cases involve activities for explicitly handling the formal planning context.
O handling of incentives, including resources and efficiency	Low	One case involves explicit actions for handling incentives.
P handling of human aspects coordination	Medium	Three cases use so-called local champions and transparent and systematic techniques for contributing to the process as a means of creating trust and engagement. One case uses a conflict management technique.

4.1. Integration across disciplines

4.1.1. A: Integration of knowledge from all relevant disciplines

All cases involve researchers and experts from several academic disciplines, which according to the sustainable process framework is one fundamental prerequisite for ensuring the use of cross-disciplinary knowledge (criterion A). Disciplines such as physical geography, hydrology, ecology, hydro-informatics, environmental science, institutional economics, economics and other social science disciplines were represented. In WPI^{+} and DEMO the numbers of researchers from the natural and the social sciences were approximately equal, while in the DIANE, VASTRA and SEAMLESS projects, the majority of the scientists were from the natural sciences and engineering. Integration of inter-disciplinary knowledge were supported by group discussions and project meetings in all the studied projects, and by workshops (DIANE, VASTA, DEMO, SEAMLESS). The design and use of the technical aspects of the projects (i.e. database set-up, development of scenarios), selection and visualization of model results using digital maps, establishment of connections between different kinds of simulation models, and the integration of this kind of technical information and knowledge into the participatory process all play an important role in supporting cross-disciplinary integration. In SEAMLESS for example, an open source software was jointly developed to support this integration in a cross project and disciplinary working group,

One problem identified in several of the cases, is that the use of simulation models from natural science may hamper cross-disciplinary integration. The time spent on data collection, model development, calibration and validation, etc. often affect how the social scientific knowledge can be used, and sometimes model practicalities rather than the participatory process itself determine when and how the integration can be made, such as the timing and design of the project workshops. This problem is reported from the VASTRA, SEAMLESS and DEMO projects, while WPI$^+$ deliberately used a less data-dependent and complex model and thus managed to avoid this problem.

4.1.2. B: Handling of different views of knowledge

While the discussions and activities described above have the potential to support criterion B, none of the cases applied *explicit* procedures aimed at handling different views of knowledge. The cases show, however, that project discussions involving several disciplines can be effective in handling the potential problems related to differences in knowledge views. The SEAMLESS case shows that discussions related to quite technical issues, such as ways of handling different kinds of uncertainties related to the model output, can lead to discussion of different ways of understanding reality and views of knowledge and could be said to serve as a learning platform for integration of different views and knowledge. Important factors affecting the capacity of handling differences in knowledge views are the interdisciplinary experiences of the involved scientists (WPI$^+$ SEAMLESS) and a project leadership that explicitly made room for both natural and social scientists (DIANE, DEMO, SEAMLESS, VASTRA).

4.1.3. C: Handling of different kinds of uncertainty

One explicit way of handling uncertainties is the development of simulated scenarios (VASTRA, DEMO, DIANE). The SEAMLESS project specifically employed structured discussions to handle different kinds of uncertainties linked to the project models used. Other than this, uncertainties were mainly handled indirectly, by means of the participatory design of the processes of discussing the output of the models (DIANE, WPI+, VASTRA, DEMO). The WPI$^+$ case, in which indexes for water and poverty were developed, shows that the systematic inclusion of different local groups' knowledge can have a considerable positive effect on the reliability of the modelled result. Also, the participatory approach brought the reliability of the model into focus in the discussions.

4.2. Integration across values

4.2.1. D: Identification of the most relevant values

All projects, except WPI+, involve activities for defining the objectives of the process, i.e. the basis for the identification of values. In relation to eutrophication (DEMO, VASTRA, SEAMLESS), both the water environmental values targeted and the values affected negatively by potential measures or policies were identified as part of the PM process. In DEMO a specific workshop was arranged where different goals/legitimate uses of water were identified and prioritized (Jonsson et al., 2011). The SEAMLESS project identified early on in the project a large set of potential stakeholders and interacted with them though out the project concerning which types and kinds of indicators that could be used (Alkan Olsson et al., 2009).

None of the cases, however, includes a fully open approach for identifying the values most relevant to the issues handled. One important reason is that the case contexts (the funding, the project-description, the legislation in focus etc.) steer and delimit the value scope of the process. Another important reason is that the disciplinary perspective of the models used strongly influences which values are discussed. In the studied cases, natural scientific models that describe physical processes in the landscape were used. SEAMLESS also includes an economic model. Most cases use existing models, although in some cases, for example SEAMLESS, the aim was to develop and improve the model, or to combine already existing models, in order to capture more aspects of the problem (and values) at stake.

In all the projects discussed here, the purpose of the participatory activities was to ensure a broader perspective in terms of values. In the VASTRA and DEMO cases this is achieved mainly through stakeholder discussions about the distribution of costs for different types of environmental measures. In the SEAMLESS case, this is done by ensuring that the models used had the capacity to assess the effects of different policy options. In the WPI$^+$ case, this was done by a carefully thought-out process to integrate the perspectives of different local groups involving a series of (7 + 7) gender separate workshops in the establishment of the indicators developed.

4.2.2. E: Rational argumentation: relating identified values to alternative choices in the planning process

Another basic component in terms of integration across values is that the identified values are explicitly linked to key choices in the planning process. It should be clear for the participants how alternative policies, plans or futures affect the most relevant values. All cases involve tools that alone and in combination support systematic handling of values in this respect, such as multi-criteria-analysis, functions for ranking of alternatives and electronic voting, indicators, GIS and simulation models showing the effect of different policy scenarios. Structured group discussions and workshops were used in all cases, and these can provide important support for rational discourse. In the DEMO case, for example, separate workshops for each involved stakeholder group were organized before and/or in between the common meetings to support structured communication in those meeting.

4.3. Participation contributing to the process

4.3.1. F: Inclusion of actors' knowledge

All cases were based on the idea that stakeholders' knowledge is important for making simulations more robust by including contextual knowledge and data that are seldom part of experts' knowledge or of official databases. One example is knowledge of the local effects of a specific flood event or the frequency of water shortage in a specific well. Such contextual knowledge is further important for the formulation of alternatives, such as how local farming procedures can be adapted to a certain environmental measure. The cases utilized several activities for integrating stakeholders' knowledge in the process, such as workshops (all), group discussions (all), boundary-spanning persons[6] (DIANE, DEMO and WPI$^+$), Participatory Rural Appraisal-techniques (WPI +) and communication via web platforms (DIANE, SEAMLESS). In some of the projects, co-produced maps played an important role; in the DEMO case, an expert produced map was corrected by local stakeholders, and in the WPI$^+$ case maps drawn by villagers were integrated with GPS coordinates and governmental maps into "thick" visualizations of i.e. access to water and sanitation by households, and the quality of irrigation services in different areas of village.

4.3.2. G: Inclusion of the actors' ideological orientations

An ideological orientation is here defined as a comprehensive set of values and normative ideas of an individual, group or society. Ideological orientations can transcend groups such as females, males, farmers, children, and NGO members. All cases include specific procedures targeting the integration of stakeholders' ideological orientations. This was achieved in the DIANE and the DEMO cases through participatory procedures that defined objectives and formulated alternative measures and by the ranking and negotiation of alternatives. The WPI+ case integrated ideological orientations by differentiating between stakeholder groups when collecting the empirical material for the WPI, such as male stakeholders from land-owning castes and female stakeholders from scheduled castes. DIANE, DEMO, VASTRA and WPI + used multi-criteria-analysis and voting techniques. In SEAMLESS, interaction meetings were held with different stakeholder groups

[6] A boundary-spanning person (sometimes also called a local champion) makes it possible for people with different backgrounds, for example local villagers and researchers, to understand each other. Boundary spanning can relate to knowledge but also to culture and language. Such a person can also have a gate-keeping role, which is of great practical importance for collaboration.

representing different perspectives in the European agri-environmental debate. In the VASTRA and DEMO cases, ideological orientations were also handled in discussions of the distribution of costs for environmental measures. Because of power issues, cases need to apply far-reaching procedures or techniques to include ideological orientations both at the level of individuals and at the level of groups (related to criteria J and K).

4.3.3. H: Participation in the most critical phase(s) of the process

The most critical phases of a process are defined by the SPF as those phases that can have the greatest effect on the final outcome of the process. In general, early steps in the process are more influential than later steps. In the DIANE case, the key authority was already involved from the start − process preparation and set-up. Stakeholders are then involved in several stages during the process, including the most influential for the process outcome. In the SEAMLESS case, the project set-up was intimately integrated with the needs of the EU Commission and EU to develop an evidence-based strategy for integrating stakeholders in the decision process for the development of the future agro-environmental policy. In DEMO and VASTRA the process preparation and set-up were influenced more indirectly by relevant authorities, but in DEMO local stakeholders (farmers) were intimately involved from the start. In these two projects, issues like the scope of objectives, the type of knowledge targeted and the sectors and actors involved etc. were influenced by the project context (e.g. composition of research group, funding opportunities). Both DEMO and VASTRA were, for example, developed in the context of the EU WFD, and hence defining the objectives was primarily a natural science issue, since the WFD follows an ecosystem-based approach. In both cases, the focus in the stakeholder discussions was on how such objectives (e.g. clean water, fishing opportunities) were evaluated. However, as the project was defined by scientists and financed by scientific research councils, stakeholder participation was weaker. The WPI+ case does not go beyond step 2, whereby the development of the index is a way of conducting this step (baseline situation). Although the WPI+ case does not involve participants in step 1, the development of the participatory WPI − which describes the water situation in a local village from the different perspectives of the villagers themselves − is a very good basis in terms of criterion H.

One important feature observed in all cases, is that the use of models makes it easier to focus on issues of choice and design of environmental and safety measures ("how can we get there?") than on broader issues of societal development ("where do we want to go?").

4.4. Participation generating commitment, legitimacy or acceptance

4.4.1. I: Procedure for defining the actors that should be involved

All cases included strategies for defining whom to involve. The DIANE, VASTRA and SEAMLESS cases use the research group as the point of departure; thus, actors are identified based on the researchers' understanding of who is most affected by the issue at hand. The DIANE project put considerable effort into this by conducting a stakeholder and an actor network analysis, largely based on interviews with stakeholders. In the WPI+ and the Demo cases, which were both locally initiated, the strategy for identification of participating actors was based on collaboration between the researcher group and a local organization (NGO), thus making use of local knowledge to define the actors. There is a risk, however, that certain groups of actors might be excluded or difficult to engage in the process, if they are unknown or not quite acceptable from the perspective of the organization first involved. There is also a danger that actors whose interests conflict with those of the involved organization will perceive the project as biased.

Several of the case studies reported that it is important to adopt an open and flexible approach in relation to stakeholder involvement throughout the process, i.e. to include new groups of actors. Thus, the DEMO as well as the SEAMLESS case found it necessary to involve private sewage system owners along the project duration.

4.4.2. J: Handling of power asymmetries

The case studies identified three main power structures which they dealt with more or less methodically: structures related to knowledge, to gender and to class. All projects use methods specifically for handling power imbalances, for example structured communication, class, gender or actor type, separated meetings, times and places of meetings and web-based communication that enable different actor groups to participate. In the WPI$^+$ case, pocket chart voting with marked votes according to villagers and government officials made it possible to distinguish major differences in perceived responsibilities between these two groups.

Even though the DIANE, DEMO and WPI+ cases utilized most of these techniques and had high ambitions in respect of handling power issues, power relationships activated during the participatory processes are complex. The transparent ranking and voting exercise in the DIANE and DEMO cases, for instance, during which participants can see how other actors have ranked different alternatives, might put pressure on actors to suppress their ideological orientations, especially those representing minority interests. In the SEAMLESS project, case studies covering different agricultural contexts involving different aspects, including power structure of the European Agricultural system, were used as a way to handle and consider power asymmetries.

4.4.3. K: Procedures to ensure that ideological orientations are not suppressed

All cases except for WPI+ include steps that aim at, or even require, consensus among the participants, either on a set of objectives, a set of measures or a plan. Creating a "common understanding" is generally considered important. All cases use series of workshops and group discussions as communication structures. Such relatively free group discussions, with consensus as the overall aim, can be problematic in terms of the possible suppression of less well-represented ideological orientations. Because the cases use specific techniques targeting power asymmetries (criterion J), however, many of the potential problems related to K are addressed.

4.4.4. L: Stakeholder learning

In the five cases studied, the groups comprised local-level actors, but also local, regional and EU-level authorities (SEAMLESS). Stakeholder learning is a central idea in all five projects, and most of the steps involve activities to explicitly support this criterion. The main activities include a wide range of techniques, such as workshops, a series of group discussions, visualization of scenarios and simulations on maps, modelling exercises, actor network analysis, and ranking and voting exercises. These activities and the design of meetings facilitate what we call stakeholder learning: stakeholders learn from each other and from the researchers about the physical system and the resource- or risk-related problems, about possible measures and their effects and about their own role, as well as the roles and perspectives of the other stakeholders. Two of the cases (DIANE and DEMO) have been specifically commended for their outcome in terms of learning. In DEMO for example, learning occurred both at the regional level, where the project to some extent served as a test bed for the implementation of the WFD, and at the local level where the involved farmers perceived their knowledge to have enriched the process.

4.5. Integration across organizations

4.5.1. M: Organizational learning

Organizational learning, as defined by the SPF, is learning within an organization that is not dependent only on one or a few individuals in that organization. If a collaborative process involving several organizations is to fulfil criterion M, the process must involve procedures to support institutionalization of the knowledge gained during the process. One example is the establishment of a shared database that is adapted to the organizations' data-managing structures (and thus easy for them to use). Another example is the formation and governance of a collaborative group which works out effective structures for integrating the knowledge produced by the group into the various organizations. The results of the local process in both DEMO and VASTRA were for instance handed over to the Water administration board as a possible basis for further development and as an example of how a local water management process could be developed and handled in the water committee's future role as part of the WFD administrative system.

Although learning is a central feature of the studied cases, and although there is indeed knowledge transfer from the projects to the participating organizations via the representatives and via outputs such as research presentations, seminars and reports, no activities are aimed directly at establishing structures necessary for organizational learning to occur on a long-term basis. In almost all cases the so-called local champions, who act as direct and permanent contact persons for the local communities, could be seen as an attempt. This strategy rests on a few individuals, however, which makes it very vulnerable.

4.5.2. N: Handling of the formal planning context

All cases involve representatives from authorities at different levels, and discussions about the formal roles and responsibilities of the actors occur spontaneously during different meetings along the way. The DIANE case involves an explicit activity for handling the formal planning context – the stakeholder analysis and the actor network analysis – which focuses on the formal roles of the actors. The DEMO case involves drawing up a plan for handling the formal context with respect to the implementation of the measures identified in the project's action plan (the output of the project).

All cases, except WPI+, are connected to one specific formal context because their goals are to provide knowledge and tools for it: the EU Floods Directive (DIANE), the EU WFD (DEMO, VASTRA), and the EU Environmental Impact Assessment legislation and the agro-environmental legislation (SEAMLESS). The processes are therefore adjusted to each context, which to a limited extent fulfils criterion N. In terms of cross-sectorial issues, however, handling of the formal planning context would entail considering all the main formal planning contexts that influence the issue at hand in an integrated manner (not only *one* legislation in focus). The aim of the SEAMLESS project was to integrate knowledge on how one policy may affect several issues hence targeting several legal and policy spheres at the same time.

4.5.3. O: Handling of incentives, including resources and efficiency

In a PM process, the issue of incentives is fundamental. Why do different participants get involved? What barriers exist, such as authority mandates, legislation, budgets and time plans? How can the process be set up to increase its efficiency and to decrease the time and money required for directly and indirectly affected stakeholders to participate? What alternative set-ups exist, and what are their pros and cons in respect of resources and efficiency? Incentives relate to both process design and to the implementation of the established plan. Some of these questions were addressed to some extent in all cases, but none involved a comprehensive and strategic consideration of them in relation to process design.

One example of how incentives were handled in relation to implementation is the DEMO case, in which a locally anchored plan of action was defined as one of the concrete outputs. This plan included a list of barriers (lack of incentives) at different administrative levels of the Swedish agricultural and water management systems, and of possible concrete activities at the local level. In the SEAMLESS case, the economic cost of different scenarios was estimated, such as private income and the cost of NP leaching.

Two cases report difficulties probably connected to incentives: The DIANE case, which made a significant effort to engage concerned citizens, observed that it is very difficult to engage unorganized citizens. The WPI+ case made an effort to engage the local authorities but failed because of the sectoral departments' unfamiliarity with working over sectoral borders (the Irrigation and the Public Health Department).

4.5.4. P: Handling of human aspects coordination

Three of the cases (DIANE, DEMO and WPI+) have an explicit strategy for creating trust and engagement. The aforementioned local champions were accepted by all sides and were reported to exert an important influence on the projects, both practically and in terms of creating a trusting and open atmosphere by virtue of their personalities and positions. Trust may have been furthered in these cases by the transparent and structured ways of contributing to the process described above, for example through the multi-criteria-analysis tool and individual voting. These cases show that the characters of the persons involved in the process and the personal relationships established are keys for the process to work well.

Several of the cases involved opposing interests which may potentially give rise to friction between the various actors. Although it did not actually come to this, the DEMO case managed conflicts by dedicating some of the group meetings to discussing the different perspectives of the opposing interests.

5. Discussion: elaboration of key research issues based on the cases

Based on the studied cases, we here detail key issues for developing PM into a procedural tool for SD, structured by three focal points of our result: 1) knowledge and learning, 2) values and democracy, and 3) organizational integration.

5.1. Knowledge and learning (A, B, C, F, H-K, L, M)

The PM cases studied illustrate an effective approach to integration of various local and disciplinary expert knowledge (see Result for criteria F, L). By using supportive tools as communication platforms, visualization tools and computer based simulations e.g. of different scenarios showing cause-effect-relationships in an understandable and transparent way, knowledge integration can be pursued. This result is much in line with what is reported from current PM literature (e.g. Dreyer et al., 2011).

A major advantage of participatory processes in general is the integration of stakeholders' knowledge (F). One problem, however, is that the knowledge of stakeholders who are not included in the process will not be represented on equal terms. Hence, when establishing a participatory process there is always the question of which and whose knowledge is integrated, at what steps, and, what priority that knowledge is given. The same applies to disciplinary knowledge integration (A, B), which is dependent on the disciplines that participate in the process, who represents the disciplines, and in which way they are represented. Designing a process for knowledge integration therefore requires careful consideration of such representation and power-related issues (H–K). This is especially true when models are used because developing most types of models is a time-consuming exercise and experiences from our projects, which mainly involve complex models, are that scientists developing the model may be very concentrated in developing and validating the model and less on integrating it with other knowledge spheres. In addition, knowledge integration in the type of trans-disciplinary projects that have been evaluated here may lead to the need to reconsider and slightly alter each individual knowledge base. We have experienced that model developers are not always open to reconsider the foundations or components of the model since this may include a lot of work and costs that may not be included in the project budget. The downside of this is that through interdisciplinary cooperation, models become more and more complex, which make them difficult to understand for non-experts. This may create an unequal power balance not only between scientific disciplines but also between model scientists and lay–people.

In relation to knowledge, it is also important that uncertainties and a lack of knowledge are handled in a transparent and comprehensive way. The studied cases mainly deal with uncertainties via structured discussions of model reliability. However, a comprehensive and systematic approach to identifying and managing all main types of uncertainties would need to be applied to provide full support in terms of criterion C. This has also been pointed out by current reviews (Voinov et al., 2016; Mallampalli et al., 2016) Some uncertainties are caused by variations of the natural systems (aleatoric) and cannot be handled by additional sampling, whereas some are caused by lack of knowledge about how the systems work (epistemic uncertainty) and relate to for example actor behavior, formal competencies and procedures (Voinov et al., 2016). Approaches from statistics, possibility theory and business management can support handling of uncertainties, but these approaches are more or less suited to a participatory context (ibid.). Current developments within the fields of adaptive management and participatory modeling are also promising and provide successful examples to draw from (e.g. Lynam et al., 2010; Bijlsma et al., 2011; Cobb and Thompson, 2012).

In all projects a mutual knowledge exchange and an increase in understanding was observed, both in relation to the issues at stake as well as to the perspectives of the "others" (L). All cases were research projects, and were thus "constructed features", embedded to a greater or lesser extent in the daily practical work-flow and decision-making processes in the geographical areas targeted. It has been argued that in order for a social learning process to go beyond individual learning it has to be situated within social units or communities of practice (as Reed et al. (2010) define social learning) and institutionalized in the organizations involved. Our results clearly imply that the development of structures for institutionalized learning within the organizations represented in the process is a key issue for developing PM in retain to SD processes (see Result for M).

Good examples of knowledge integration could be taken from several of the projects. However, DEMO is exemplary: here it was clear that the open discussion in a larger stakeholder context on model output or on perspectives, as well as ideas forwarded from the stakeholders, expanded and concretized the different aspects of the problems at stake. It opened up new perspectives both on the type of scientific information that was relevant for stakeholders as well as on the areas in which scientific facts could actually enhance learning on the part of both stakeholders and scientists with respect to the strengths and weaknesses of the models used. With input from experiences from DEMO, a new hydrological model, HYPE (Lindström et al., 2010) was developed which, contrary to the model concept used in DEMO, enables seamless modelling of hydrological and water quality processes, which if used in other participatory processes probably will speed up the modelling activities and facilitate its use.

5.2. Values and democracy (D E G H I J K)

All the cases show large potentials in terms of value integration, mainly because of the tools used − multi-criteria-analysis, functions for ranking of alternatives and electronic voting, indicators, GIS and simulation models, structured group discussions and workshops. This is one of the main strengths of PM identified here (see E and G). Used carefully, and in combination, these tools have the potential to make NRM and DRM processes transparent, value- and knowledge-based, and to support democratic deliberation, a fundamental aspect of sustainable procedures (Miller, 2013; Robinson, 2004).

One other basic condition for a sustainable procedure, however, specifically in terms of integration, is that it is able to embrace *all* the most relevant values connected to the issue handled (D). In the studied cases, competing or complementing values are not entirely part of the value basis applied by the tools mentioned above; they are usually defined from within one discipline involving just a few individuals. This indicates a problem that needs to be handled for PM to become an approach for SD procedures as understood by the SPF. The value basis applied is closely related to the formulation of project objectives and the context of funding, and also to the scope of aspects covered by the simulation models. A cautious approach to this issue, however, would facilitate a broadening of the value basis at an early stage of the process and thereby avoid the "incomplete picture problem".

Connected to the issue of value integration, the cases indicate that PM has also a large potential to support a democratic participatory process (see Results for crit. H-K). The PM process serves as an arena where different groups and people can meet and deliberate. The cases show that the models, the related tools and process can assist in developing a transparent, knowledge-supported, rational and democratic deliberation. However, some issues need greater consideration in order for PM to utilize its potential fully in terms of democratic participation. These are: Who is *represented* in the process? (I); At *what steps* in the process are participants involved? (H); and, How can one ensure that certain actors' views are not suppressed during consensus-based processes? (K). The cases show that the actors represented and the issues they have an influence on are primarily steered by the project context and set-up. Further, the actual use of advanced simulation models may shift the focus of the participatory process to issues of design and selection of measures (how can we get there?) from more fundamental issues (where do we want to go?). A cautious approach in the process design and project set-up is therefore vital.

DIANE provides a good example of how identification and rational argumentation involving the most relevant values can be brought to the fore. The objectives (here analogous to values) of the DIANE process – flood risk safety levels and critical infrastructure to be secured – were identified by means of discussions involving the participating actors early on in the process. A participatory modelling exercise was integrated in the collaborative web platform and applied during the workshops. The participants ranked the most important objectives and alternatives by giving points. In a multi-criteria-analysis, alternatives were ranked by the participants using both quantitative and qualitative expressions of performance in relation to the identified values (Evers et al., 2012a, 2012b). In the first step, each stakeholder evaluated and ranked the given flood risk management alternatives according to her/his own preferences. In the second step, the individual rankings were aggregated to a group ranking with transparent presentation of individual positions versus the group's and by adaptation of the group ranking by adjusting individual rankings, following negotiation activities on a virtual platform. For this purpose a chat-like interface was provided, which together with the fully transparent presentation of the individual and group profiles enabled participants to engage in discussions and negotiations.

5.3. Organizational integration (M, N, O, P)

The cases provide low to medium support for organizational integration, such as organizational learning (M), adjustment to a formal planning process (N) and handling of incentives for collaboration, such as time efficiency (O), and handling of the human aspects of collaboration (P). If PM is to be developed into an instrument for effective use in practice, procedures for organizational integration clearly need to be further refined. One possible explanation for the weak support is that all studied cases are research projects and not fully connected to real-world policy processes. This explanation is supported by the fact that it is the DIANE and DEMO cases, both designed as planning processes culminating in collectively agreed plans (later used as a basis for formal plans), that include specific procedures for handling the formal planning context (N). However, as discussed in relation to value integration, the policy context may also delimit the scope of value basis for the process, for instance by elevating the priority of the values that fall within the responsibility of the authority that leads the process.

In order for PM to become an approach for SD as process, ways to support criteria M-P need to be carefully developed. Currently these issues are much less discussed in the current PM literature compared to the issues raised above (knowledge and learning, value integration). PM has many inherent features that can support organizational integration, such as the creation of shared databases and tools for communication and co-creation of knowledge. It is therefore of outmost importance to develop our knowledge on how to make use of this potential. In addition to the related questions already formulated, key questions that should guide such research are: How can PM processes be explicitly connected to the decision-making systems that surround them, such as decisions at different geographical scales, different policy domains, and by elected politicians? How can practical thresholds to participation, such as lack of time and other resources, be handled? And how can the fact that the success of PM is dependent of socio-psychological issues be systematically and practically handled (i.e. ensuring that a well-designed PM process does not fail because one person (the real enthusiast) leaves the process)?

6. Key issues identified for PM as a tool for SD as procedure

Based on the synthesized cases, key research issues for developing PM into a tool for SD as a procedure have been elaborated. The five cases are not selected to be representative of the PM field as such, but the issues identified here can serve as an indication and a starting point for continued discussion. The key issues identified are:

- PM shows large potential for and provides good support to knowledge integration and learning. To reach its full potential, the following research questions need to be explored further:
  - How can the most relevant expert and contextual knowledge be integrated in the PM process? (issues of representation and power)
  - How can uncertainties and lack of knowledge be handled in full-covering and systematic ways in PM?
  - How can PM be designed to support institutionalization of the knowledge generated in the process amongst the actors and organizations that are not directly involved?
- With respect to value integration and systematic and transparent handling of values, the cases indicate that PM has a particularly large procedural potential. To reach its full potential the following research questions are important:
  - What and whose values are represented in the process?
  - At what steps in the process are they involved?
  - How can it be ensured that certain actors' values are not suppressed during consensus-based processes?
- PM needs to be developed further in respect of organizational integration,[7] especially if the goal is to develop PM into a tool that can be implemented at larger scale in practice. Important questions are:
  - How can PM processes be connected explicitly to the decision-making systems that surround them, such as decisions at different geographical scales, different policy domains, and by elected politicians?
  - How can practical thresholds to participation, such as lack of time and other resources, be handled?
  - How can the fact that the success of PM is dependent on socio-psychological issues be systematically and practically handled? (i.e. how can one safeguard that a well-designed PM process does not fail because one person, the real enthusiast, leaves the process?)

Further exploring the potential of PM for SD by doing a broad comparative study of PM practice presented in the literature would generate important and relevant knowledge in terms of SD procedures and would be a valuable complement to the in-depth research approach used here. Furthermore, the methodology applied in this study would need to be used in more real-world cases involving real decisions. Because such processes are trans-disciplinary in character, alliances need to be built between scientists and practitioners. Studies could evaluate the usefulness of PM in a real context and explore efficient levels of ambition in terms of model complexity, intensity of participation, etc.

These key issues identified here provide a basis for developing PM further in respect of SD. The SPF may be used as a theoretical and methodological point of departure for such studies, for example in developing a generic definition of sustainable PM procedures, or in designing a more or less specific PM process. For such work, trans-disciplinary research designs might be effective due to their systematic interaction between theoretical, general knowledge types and contextual, specific knowledge types.

[7] Literature on organizational learning, multi-level governance, collaborative planning and leadership and social psychology can provide valuable insights for such work (e.g. Rashman et al., 2009; Jordan and Lenschow, 2010; Ansell and Gash, 2008; Muller-Seitz, 2012).

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