Van Cauwenbergh, N., A. Ballester Ciuró, and R. Ahlers. 2018. Participatory processes and support tools for planning in complex dynamic environments: a case study on web-GIS based participatory water resources planning in Almeria, Spain. *Ecology and Society* 23(2):2. https://doi.org/10.5751/ES-09987-230202

Research

Participatory processes and support tools for planning in complex dynamic environments: a case study on web-GIS based participatory water resources planning in Almeria, Spain

Nora Van Cauwenbergh [1], *Alba Ballester Ciuró* [2,3] *and Rhodante Ahlers* [4]

ABSTRACT. Democratization of water resources management through the involvement of stakeholders has been widely advocated over the past two decades. In light of mediocre results of such processes and severe criticism of the claimed benefits of stakeholder involvement, there is continued need for improving these processes and for supportive tools through which stakeholders can collaborate in decision making. In response to new European legal requirements, an innovative planning process was initiated to facilitate a productive dialog among stakeholders to develop a shared river basin management plan. This paper presents and discusses the results of action research on this participatory planning process in a semiarid river basin in Spain. We discuss: (1) to what extent participatory processes and tools address the needs of stakeholders and planners, (2) what enables or disables implementation in a complex socioeconomic reality, (3) to what extent the participatory approach leads to alignment with policy embodying a new water management paradigm, and (4) how tools can be flexible and their use adapted to changing contextual dynamics. Research results confirm the potential for increased participation assisted by web and GIS tools, however, such processes are highly sensitive to changing contexts as well as the mandate and continuity in support from management authorities. Fragmentation of responsibilities in the water arena and the weak interpretation of the coordinating role of the water administration undermine the democratic ruling sought for by public participation. Improved methodologies to evaluate and improve the effectiveness of participation are required, and tools need to be flexible in design and used in a facilitated participatory process, adaptable to changing contextual dynamics.

Key Words: *decision support; integrated river basin management; participatory spatial planning; water policy; web-GIS tools*

INTRODUCTION: THE CALL FOR DEMOCRATIZATION OF DECISION SUPPORT IN WATER RESOURCES MANAGEMENT

Natural resources management and planning, and the planning of water resources in particular, are increasingly framed in a participatory setting, as prescribed by international policies such as Local Agenda 21 (United Nations 1993), the Aarhus convention (United Nations Economic Commission for Europe (UNECE) 1998), and the EU Water Framework Directive (WFD) (European Commission (EC) 2000). Public participation as a fundamental component of integrated water resources management (IWRM) is motivated by the assumption that public participation would facilitate more informed and creative decisions; increase the level of transparency and democratization; improve the acceptance and effective implementation of politics; and create a broader knowledge base and contribute to social learning (Barnes et al. 2007, Mostert et al. 2007, Muro and Jeffrey 2008, Reed 2008, Huitema et al. 2009).

However, these claimed benefits have received severe criticism and, as highlighted in the review by von Korff et al. (2012), the extended scientific discussion of the past decade has not been able to satisfactorily answer the two fundamental questions on the design and implementation of participatory water management planning raised by Webler and Tuler (2001): "(1) what are the benefits of using participatory approaches and (2) how exactly should these approaches be implemented in complex social-ecological settings to realize these benefits?" The persistent problem for planners and activists involved in river basin planning is how to construct a process that meets the needs and goals of planners, affected stakeholders, and the general public while producing implementable and effective policy outcomes in a cost-efficient manner.

In Europe, the conviction that public participation is beneficial for water resources management is reflected in the obligations established by the WFD (EC 2000) to include public participation in hydrological planning. This legal obligation has changed European water politics on paper and challenged water administrations responsible for its implementation on the ground (Martin-Ortega 2012). Compliance with the law has led to a rapid proliferation of participation processes in the elaboration of river basin management (RBM) plans, pushed forward by the water administrations of European member states. As elsewhere, the results of the European participatory processes have been rather diverse. Although empirical evidence shows that better mutual understanding results in tangible improvements and appreciation for different perspectives in some cases (Huitema et al. 2009), public participation often remained limited to providing information or consultation (Mostert et al. 2007, Huitema et al. 2009). Examples show that stakeholders considered themselves as not very relevant (Jonsson 2005), as being entangled in power conflicts (Warner 2006), or as having no real power at all (Page and Bakker 2005).

More recent observations on European water resources planning processes come from a 2014 review by the European Environmental Agency (EEA 2014) and scholars such as Parés et al. (2015), Söderberg (2016), and Voulvoulis et al. (2017). Even

[1]IHE Delft, [2]Autonomous University of Barcelona, [3]Foundation for a New Water Culture, [4]SOMO, Centre for Research on Multinational Corporations, The Netherlands

after decades of research on public participation, theorizing, and developing related policies and their implementation, the studies reflect a general international trend of mixed successes, failures, and remaining challenges. Among the critical issues identified are the composition of the stakeholder group and the associated external and internal power relationships (Cleaver 1999, Faysse 2006), political commitment (Beierle and Konisky 2000, Reed 2008), increased time and budget needed to make decisions (Lundgren and McMakin 2009), the difficulty in balancing efficiency and inclusiveness (Pelling 2007), scale and ownership (Pelling 2007, Fekete et al. 2009), and a general lack of participation (Reed 2008) motivated by the lack of capacity or mandate to influence decision making (Huitema et al. 2009). There is a growing recognition that the sociopolitical and cultural context in which the participatory process is embedded matters (Mostert 2003, Martin-Ortega 2012, Barnaud and van Paassen 2013, De Vente et al. 2016). Scholars such as Mollinga (2008) warn that considerable differences persist between the scientific positions, the political discourse, and the social reality in water management.

Several tools have been developed to improve participatory processes in terms of transparency, trust, collaboration, and information exchange (Tan et al. 2012), including web-based applications. However, a number of problems with the development and use of these tools have been identified, including issues with reliability of user-generated content, social exclusion due to the dependence on technology, and the interpretation and implication of digital maps (Pfeffer et al. 2013).

In order to address the current challenges of participatory planning processes and the need for improved methods and tools, the ALTAGUAX research project was designed. Over a period of 3 yr, using an action research methodology, processes and tools were developed and tested for their potential to encourage and facilitate participatory planning. The objective of this paper is to present the approach and outcome of the ALTAGUAX project and to subsequently use the results to discuss how certain challenges of participatory planning processes can be addressed.

Implemented in the southern Spanish Andarax river basin (Fig. 1), the ALTAGUAX project aimed at improving water management in a highly agricultural productive, heavily water-stressed basin that faces multiple challenges by involving stakeholders in a mediated planning process assisted by a custom-developed web-based geographic information system (GIS) tool. With an action research approach, the scientific goal of the project was to address concerns raised by Webler and Tuler (2001) relating to the benefits of using participatory approaches and their implementation in complex social-ecological settings. In addition, we aimed to understand how the use of web-based participatory GIS (PGIS) can contribute to producing those benefits while dealing with abovementioned barriers and challenges. The objective of the web-based PGIS tool was to enable discussion, facilitate problem identification, and contribute to the formulation and evaluation of measures through solution-oriented provision of information.

The case analysis is intended to address the following questions:

1. To what extent do the participatory process and tools address the needs of the diverse stakeholders while allowing for the professional mandates of planners?
2. To what extent are promises made in stakeholder meetings backed up by (financial) commitments to put them into practice? What enables or disables the implementation of measures in the plan?
3. To what extent does such a participatory planning approach contribute to alignment of existing water management paradigms with the new ones introduced by the EU water policy?
4. How can tools be flexible and how can their use be adapted to changing contextual dynamics?

Under the assumption that context and boundary conditions of a complex socioeconomic and political reality are crucial in determining the outcome of public participation, we investigate how processes and tools can be designed in such a way that they produce implementable results.

In this paper, we first describe the features of the basin, followed by a description of the participatory process and tools used. The analysis that follows focuses on the interplay between context, participatory processes (and tools), and outcomes, as well as focusing on the opportunities and challenges for increased democratization of participatory planning. To measure its effectiveness, we compare the recordings of the participation process with the final budget allocation per action line in the plan. Finally, recommendations are given for improved participatory planning processes and their supporting tools.

METHODOLOGY: ANALYSIS OF PARTICIPATORY INTEGRATED RIVER BASIN PLANNING IN THE ANDARAX RIVER BASIN

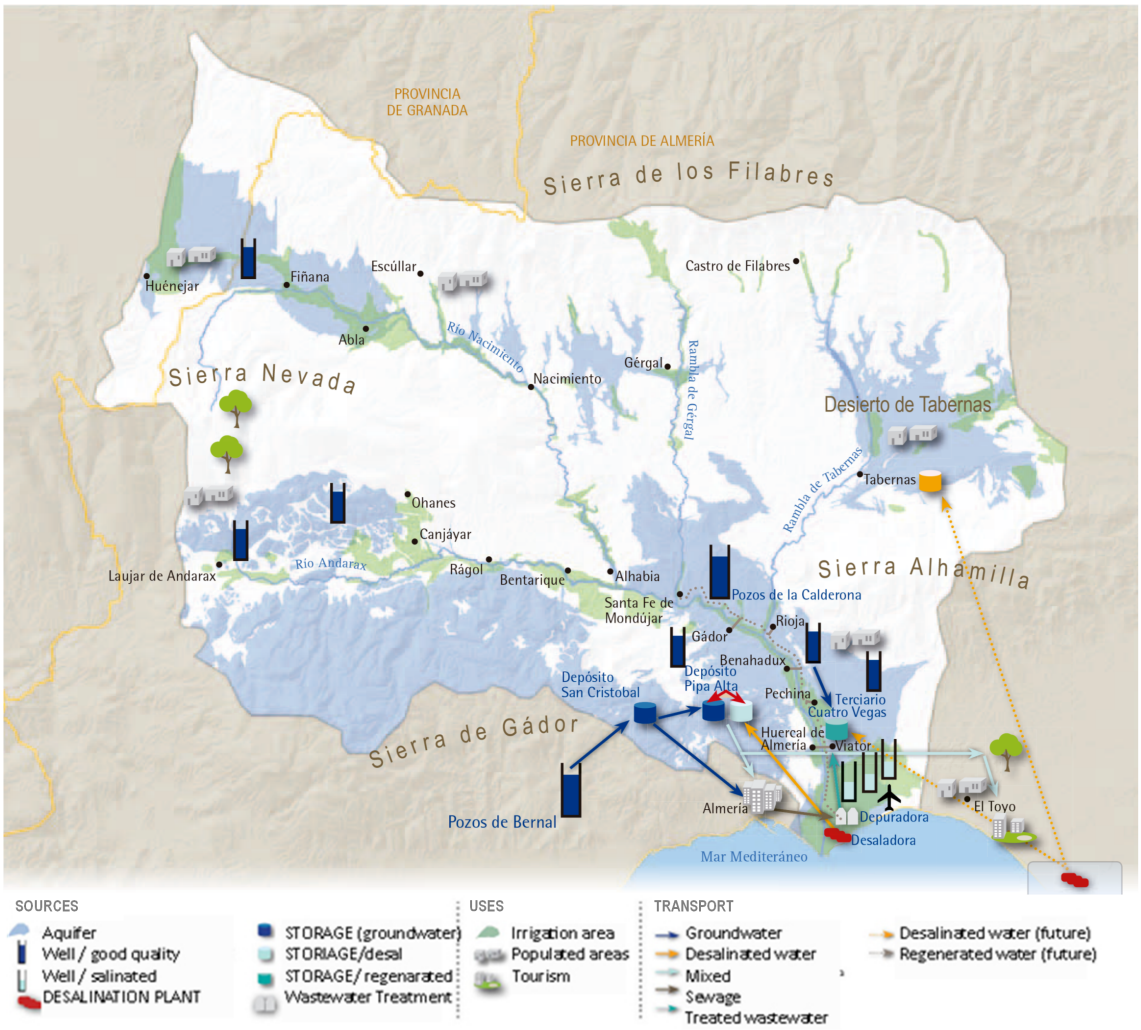
Case study, institutional and political context

The Andarax basin was targeted by an action research project in 2009 to elaborate water management alternatives that are compatible with the EU policy objective of having water bodies achieve "good status" (good chemical, physical, and ecological status) by 2015 (EU 2000). The Andarax river basin in the province of Almeria, located in the southeast of Spain, is one of the most arid regions in Europe. It is characterized by its scarce (200–350 mm/year) and irregular rainfall. The basin covers an area of 2,000 km², comprising an alluvial plain of about 250 km², Europe's largest semidesert area, and four mountain ranges, with the highest peaks reaching over 2,000 m.

Traditionally being a poor and remote Spanish province, the area was transformed by an economic boom at the end of the 1960s, based on intensive agriculture under plastic greenhouses (Sanchez-Picón et al. 2011). With over 30,000 ha under plastic (Junta de Andalucia 2017), the area is now covered with the largest concentrated surface area of greenhouses in the world. Income in the province has risen rapidly to become one of the country's highest, and population has increased from under 390,000 in the early 1970s to over 700,000 in 2016. Over 60% of the horticulture produced in Almeria is exported, 55% or over 1 million tons of which are consumed in the European Union, with the United States and Canada being important overseas markets (Frutas y Hortalizas de Almería (Fhalmeria) 2006).

Limited availability of surface water means that demand in Almeria can only be satisfied by extracting groundwater. Whereas the use of groundwater was traditionally sustainable, the rapid

Fig. 1. Andarax river basin, schematic of water sources, uses, and transport.



growth of intensive agriculture in the 1970s–1990s took place in an uncontrolled fashion (Aznar-Sanchez et al. 2011), and unregulated installation of pumping capacity has led to pumping rates that double and at times triple the recharge rate. This has endangered both the integrity of the aquifer and the economic growth model depending on it (Sanchez-Picón et al. 2011, Van Cauwenbergh and Idlallene 2012). In light of growing agricultural and urban water demands, additional, unconventional resources have been introduced with poorly documented externalities that need adequate coordination and management (Lopez-Gunn et al. 2012).

By late 2004, the area's water management was brought under the EU framework research (EU FP6 ALERT project—COCE-CT-2004-505329, download final report at http://cordis.europa.eu/result/rcn/47798_en.html), and one of the first EU-subsidized desalination plants was commissioned to be built in the area. The plant was built as part of the national "Actuaciones para la gestión y el uso del agua" program (AGUA; or Actions for Water Use and Management, developed by the Ministry of the Environment) in 2004, to provide a decentralized and locally controllable response to the so-called structural water deficit in the Spanish southeast without entering into a highly problematic interbasin transfer (Swyngedouw 2013). At the time, links among operation of the desalination plant, seawater intrusion, and water extractions spurred the creation of a prototype decision support system (DSS). This DSS prototype enabled investigation of the impact of different management alternatives and optimization of groundwater and seawater pumping to avoid further seawater intrusion. As part of its development, uses and users in the basin were characterized, and users were interviewed about their management practices, problems, and preferences as well as their outlook on the future (Van Cauwenbergh et al. 2008).

At the time, the river basin organization was starting to feel the consequences of the profound policy change embodied by the ratification of the EU WFD into Spanish legislation in 2003. Athough this change imposed increased transparency (Sauri and

del Moral 2001), local representatives of the river basin organization remained highly reluctant to share data on water use with researchers. Nevertheless, at the regional level, some officers of the overarching water agency started to push for a change in mindset to comply with the EU WFD principles and engaged in discussions on how to incorporate these principles into their planning process. In 2009, the regional water administration requested the authors develop an action research project on the official planning process in the Andarax basin through the introduction of a downscaled active participation process. Beyond seeking socially acceptable answers for a series of stringent groundwater management problems in the Andarax basin, the project aimed to draw lessons from this experiment to improve planning in the larger Andalusian region. The intention was twofold: (1) to develop a procedure to comply with an ambitious reading of the policy prescriptions and (2) to analyze how existing procedures could be improved and what capacities, tools, and resources were necessary to assist such a process in a meaningful way. The authorities guaranteed full support of this action research project that would launch a new participation model through which possible improvements in the official planning and participation processes could be identified.

At the same time, the Andalusian planning office underwent changes in staffing and procedures in order to respond to the new European legal demands. New staff members with profiles outside the field of civil engineering entered the water agency, slowly changing the so-called old "concrete and steel brotherhood" (Swyngedouw 2007, Lopez-Gunn 2009). Nevertheless, these changes mainly occurred at the higher regional level, and many of the local staff remained. At the start of the new planning cycle, the water agency subcontracted a consulting firm to include new data sets so as to provide the reports for the EU WFD article 5 concerning the analysis of the "status of the water bodies." The limited capacity of the subcontractor to cover such a large territory resulted in inadequate data to remedy the serious lack of sound— or at least transparent—data underlying the previous and historical planning exercise.

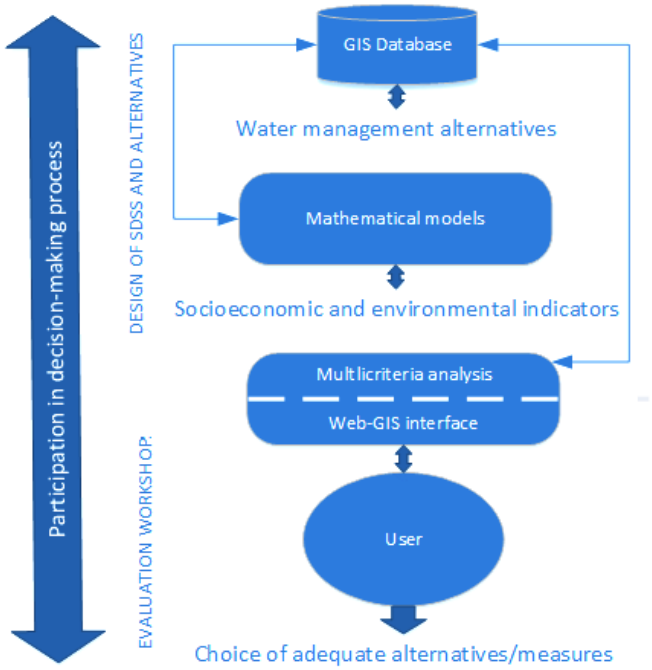
ALTAGUAX project and tools design

In view of a context with low data quality and recent institutional changes pushing for democratization of the decision making, the ALTAGUAX project developed a two-tiered strategy: (1) enlarge the table of stakeholders involved in the planning process and (2) provide agreed-upon data for that table. To achieve the latter, a GIS-based DSS was developed (Fig. 2). This spatial DSS (SDSS) allows the evaluation of socioeconomic and environmental impacts of different management strategies in an objective, informed, and optimized way, using multicriteria analysis (Van Cauwenbergh et al. 2008). The tool would incorporate data provided by the water agency (through the subcontractor consulting office) and ground-truthed through collaboration with local research institutes and stakeholders.

Multistakeholder platform: engagement process and workshop design

Based on a stakeholder analysis (Reed et al. 2009), a representative number of stakeholders were invited to participate in a series of workshops (Fig. 3). This selection was based on the relevance of stakeholders to water management in the basin, measured by a number of criteria such as representativeness, type of water used, involvement in conflicts, and interest of the stakeholder to participate in the process. Special effort was made to encourage the participation by valuable but unmotivated stakeholders, such as representatives from municipalities and the business sector. Careful attention was given to creating a multistakeholder group that reflected the heterogeneity of stakeholders as well as the basin, and represented the main interests in the basin. This resulted in a working group, or multistakeholder platform, composed approximately of one-third direct users (municipalities, irrigation associations, and public and private water companies), one-third institutions (regional and provincial administration and government), and one-third "indirect" users and interests (rural development groups, scientific/technical experts from different backgrounds, ecologists, etc.). Details on the working group composition per workshop can be found in Fig. 4.

Fig. 2. Architecture of the spatial decision support system (SDSS), with (1) a spatial database manager, (2) a scenario and alternatives generator, and (3) a user interface embedded in a web 2.0 environment.



To facilitate the introduction of stakeholder knowledge into the official decision-making process as well as into the design and input data of the SDSS, a series of workshops were organized to discuss and evaluate problems and measures. Five stakeholder workshops were organized, taking roughly 6 h each, over a total time span of 30 mo. To support the workshops, the SDSS was embedded in a webpage with useful information for both the plenary and working group debates, including functionalities that are typical for web 2.0 and social networks, such as a blog, a comment system, and a feedback system.

The content and objective of each workshop and the work related to the web-based tool is presented in Fig. 3 and moves from problem identification and initial tool consultation, to discussion of indicators and measures, and testing with the web tool, and

Fig. 3. Content of the five workshops and development of the website, with evolution of the SDSS and website in the bottom part of the circles and detailed on the right.

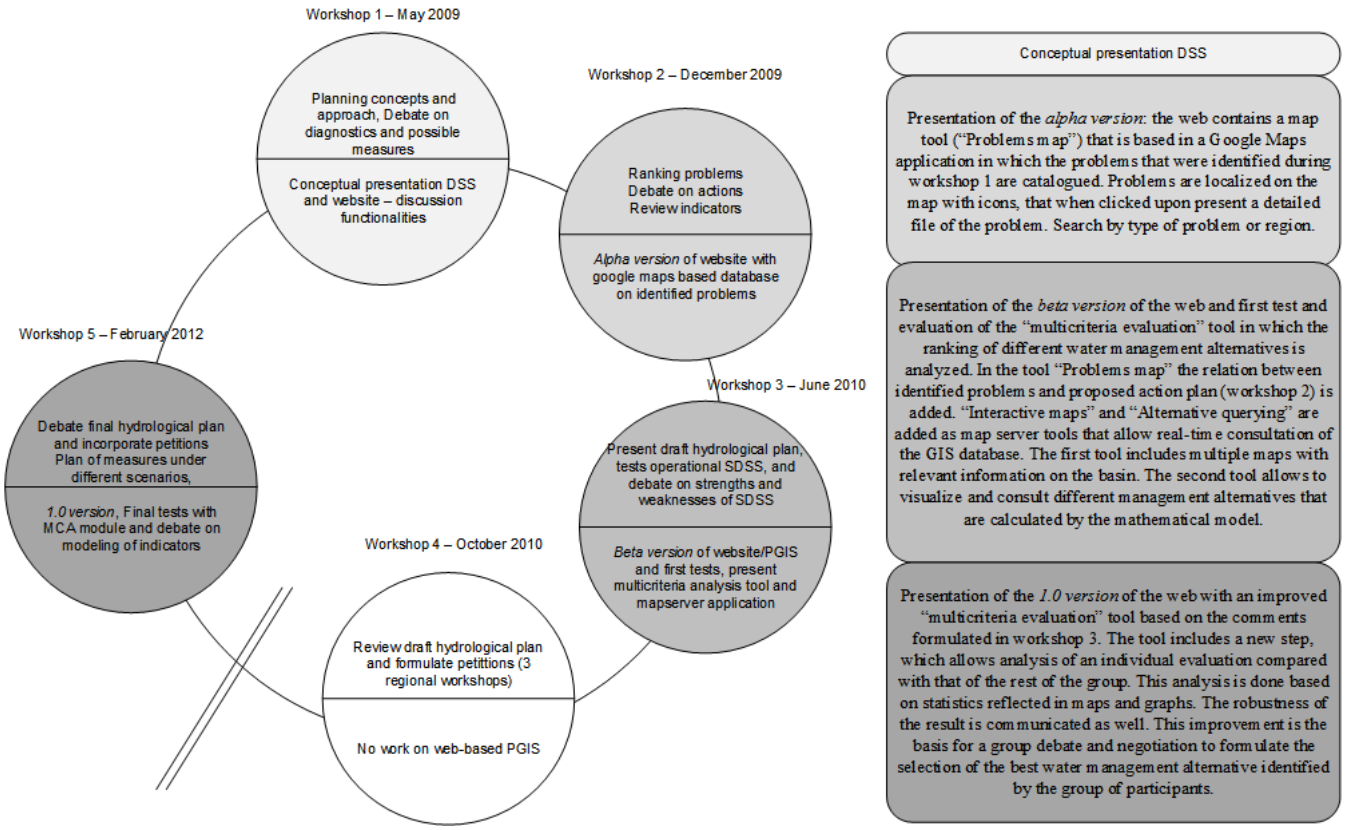
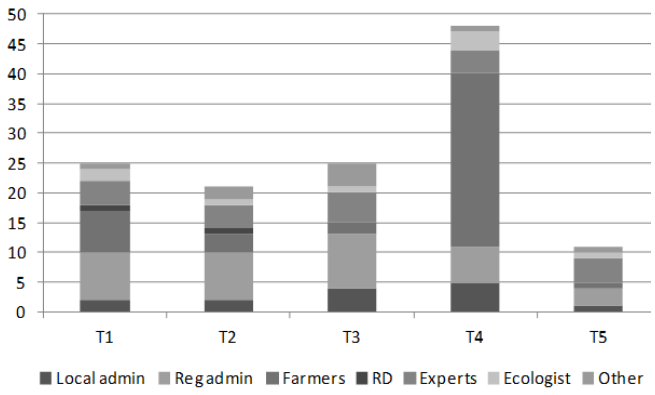


Fig. 4. Number of stakeholders participating in the workshops per category (local administration, regional administration, farmers, rural development groups, experts (law, economics, ecology, and hydrology), ecologist groups, and other (private companies, consumer organizations, media).



finally to evaluation of measures. Workshop 4 coincided with the publication of the River Basin Management (RBM) draft plan and included a participatory analysis thereof to compare the draft plan and the results of the previous workshops to identify whether corrective actions were needed. These were formulated using the established legal procedure of petitions against the draft plan. Thus, workshop 4 was split into three separate sessions organized in different areas throughout the basin to ensure continued participation of stakeholders. In the aftermath of the global financial crisis, the participatory planning process was put on hold due to funding discontinuity after workshop 4. A fifth and closing workshop was organized 14 months after workshop 4 and included a final debate of, and proposal for, water management alternatives for the Andarax river basin using the SDSS.

Design of the web-embedded spatial decision-support system

The SDSS is embedded in a webpage and has three principal components: (1) a management system for the spatial database, (2) a mathematical model to create water management alternatives quantified by a set of indicators, (3) an evaluation tool based on multicriteria analysis. Whereas the skeleton was predefined by researchers, several of its components have been codesigned by stakeholders (see Appendix 1). The codesign was done through joint definition and selection of indicators underlying the multicriteria analysis, discussion of visualization options, and evaluation of functionality and usability during workshops. Subsequently, the tool was adapted between workshops to incorporate stakeholders' suggestions.

The tool is innovative in that it combines the experiences from multicriteria analysis-based water management planning (e.g.,

Kallis et al. 2006, Refsgaard 2006, Straton et al., 2011), spatial decision making (Bosque Sendra, 2001), participatory GIS (e.g., McCall and Dunn 2012), and participatory and collaborative modeling (e.g., Sandker et al. 2010, Hare 2011, Basco-Carrera et al. 2017) with web-based dynamic design used in environmental virtual observatories (e.g., Karpouzoglou et al. 2016). By developing it in a participatory action research approach, it addresses the unexplored potential of applying participatory methodologies to enhance stakeholder-driven investigation in web-based tools that is highlighted by Karpouzoglou et al. (2016). Furthermore, it is important to specify that the tool is explicitly used as a parallel flexible narrative in an iterative decision-making process. Through the use of maps and a web-based communication platform, stakeholders discussed the quality of the RBM plan under construction.

Conceptual framework and combined quantitative and qualitative analysis

The analysis of above-described ALTAGUAX participatory planning process focuses on links between (1) context, (2) process and tools used, and (3) outcomes. Therefore, we use a combined qualitative and semiquantitative approach based on the conceptual framework on environmental governance by Newig (2007). The participatory process is defined as an interaction between multiple stakeholders and information. Elaborating on Newig (2007), we consider that both the web-based PGIS tool as well as the engagement process (workshops and interim feedback meetings) are instruments that influence the flow and assimilation of information as well as stakeholder relationships through processes of motivation, capacity building, and mediation. We consider fairness, accountability, and transparency as important qualifiers of the process. Outcomes of the process are not only tangible decisions (such as the type of water management to be implemented reflected in the plan) but also trust, empowerment, social learning, and knowledge generation. The following contextual factors are considered to shape the process and its outcomes: power relationships, complexity of issues, policy priorities, social capital, information/knowledge, mandate, and material constraints. Transparency is also an important qualifier in terms of context and outcomes.

We start our analysis by reviewing the results generated in the ALTAGUAX process: from problem understanding, to generation of indicators and prioritization of measures. Second, we analyze the link between participatory process and its tangible outcomes by comparing the measures recorded in the workshops with measures established in the draft and final plan, as well as with the budget allocated to measures in the final plan. Finally, we use a questionnaire on user satisfaction, together with empirical observations during the workshops and indepth interviews with five key participants to discuss the contribution of the ALTAGUAX approach to tangible and less tangible outcomes while considering the abovementioned contextual factors. The five indepth interviews (with respondents being the legal expert, large irrigator, environmentalist, former water agency head, and provincial government representative) were organized around the fifth and last workshop and contained questions about the perceived outcomes of the project and link to the resulting plan as well as the role of workshops and the web tool.

RESULTS

In this section, results are presented in four parts: (1) the outputs of the workshops, such as cocreated knowledge on problems and management options, as well as indicators used in the web-tool (the process); (2) analysis of workshop narratives vs. measures recorded in official planning documents (the outcome vs. process); (3) participation and user satisfaction in and between workshops; and (4) results of indepth interviews and observations during the participatory planning process (connection of context–process–outcome).

Results from participatory planning workshops—outputs and role of the web tool

The outputs from the facilitated debates in the workshops are a prioritized list of problems and potential measures as well as a set of indicators to evaluate those measures as part of a codesigned multicriteria analysis tool. Stakeholders estimated that groundwater overexploitation, knowledge, and governance issues pose the strongest threat to the development of the basin. This was shown by ranking these three problems as first, second, and fourth most important and linking 15 out of 25 measures to them in the first and second workshops. (The analysis was based on recordings contained in workshop reports, *Informe Taller 2* and *Informe previo Taller 4* by Van Cauwenbergh et al. 2011, available online at altaguax.unesco-ihe.org)

This ranking was the result of an intense mediated process, including knowledge capture from different sources, capacity building, knowledge cocreation, and priorization. The discussion of the main management problems in the catchment started by contrasting the official significant water management issues (SWMI) with the results from two inquiries and semistructured interviews with Andarax stakeholders performed in 2005–2006 (Van Cauwenbergh et al. 2008). The bottom-up findings from 2005–2006 were checked and reaffirmed with key stakeholders at the start of the new planning process in 2009 and used for the preparation of workshop 1. All invited stakeholders received links to the official planning documents on the Andalusian water agency website when available. The general public was targeted through a press release.

Information was exchanged with the consulting firm drafting the official RBM plan; however, the raw data on water users and extracted amounts used in the official planning were not available to researchers. Both the data presented in the workshops as well as data recorded during the participatory planning process were uploaded on the web platform, either in document or map form. As such, stakeholders could consult and check the hydrological and socioeconomic data used in the workshops and plan formulation. This increased transparency while engaging stakeholders in discussing the quality of the RBM plan under construction.

One such important discussion was on the hydrological data that were used in the official planning process as large differences were observed with data used by the researchers (for example on the extent of deficit in the water balance, on the link between saltwater intrusion and desalination plant operation, and on the natural or industrial pollution sources). Through a facilitated debate around different data sources and inclusion of experts in the discussion, the multistakeholder group was guided to a consensual understanding of the hydrological dynamics and problems. The

Table 1. Discrepancies and congruencies between top-down and bottom-up planning diagnosis and identified measures

SWMI and draft river basin management plan= top down	Stakeholder workshops= bottom up	Final river basin management plan
Highlighted and recorded problems/issues		
A number of problems are listed in separate categories: demand satisfaction, environmental objectives, extreme meteorological events, and governance and knowledge It was observed that following issues were not listed: • Presence of cesspools • Invasive species • Information and governance issues	Problems emphasized during the workshops: • Inadequate monitoring and control, lack of responsibility, and water use policy • Inadequate knowledge, control, and maintenance of water supply infrastructures • Malfunctioning of organizational structures • Not applying the principle of cost recovery • Lack of information, awareness, and education	In a comprehensive document and appendices, the final RBM plan includes all problems highlighted in the SWMI and stakeholder workshops. However, these are listed without prioritization and thus are difficult to analyze.[†]
Measures (according to priority)		
Focus on demand satisfaction with emphasis on: • Improved infrastructure • Irrigation modernization • Connection of Carboneras desalination plant to upstream Tabernas areas	• No politicization of water • Adapt water demand to real availability • Promote natural recharge • Recover traditional activities • Full cost recovery • Diversify supply sources • Expedite the processing of administrative permits and sanctions • Consider vulnerability maps, ecocondition agricultural aid, and promote natural fertilizers	No clear priority of measures: the final recording in the plan presents a comprehensive and balanced list of measures with ample attention to governance and knowledge and demand satisfaction and, to a lesser extent, environmental restoration and pollution control. However, budget allocation implicitly prioritizes supply-oriented infrastructure (over 80% allocated to infrastructure[‡]) (Fig. 3)

[†]The final plan is a 359 page document with three appendices, 11 annexes, and an environmental sustainability analysis report (total over 3,000 pages). The importance of monitoring and law enforcement is, for example, mentioned in Annex 10, page 28: "an inventory and implementation of control and sanctioning mechanisms foreseen in the legal framework must necessarily constitute a work of priority in the new RBM plan."
[‡]Part of this budget is allocated to irrigation modernization programs that are contested as demand-management or efficiency measures (Lopez-Gunn et al. 2012, Berbel and Mateos 2014)

role of the tool here was to support flow of information among stakeholders by visualization of data. Indirectly, the tool also contributed to the proposition of a more integrated approach to both understanding and tackling water management problems as a result of discussions about the indicators (listed in Appendix 1) and choice/preference protocol used in the tool. Stakeholders would, for example, move from a more conceptual discussion on the procedure for quantifying the energy cost indicator to a discussion on alternative data sources on electricity use to quantify pumping costs given the weak mandate and law enforcement on the ground of obligatory pumping logs. The discussion also raised further issues such as the substantially higher contribution of energy costs to the full production costs of greenhouse farming compared with water, highlighting a water price that is not representative of the added value generated and eventually leading to the formulation of a measure to adjust the water price to its value. A final debate on the energy cost led to a discussion of the energy impact of a supply-oriented strategy such as desalination vs. demand management strategies.

However, the role of the tool was limited to the workshops itself. Although the tool was intended to serve as a continuous source of information in between workshops, web statistics showed that the working group was logging in just before or during the workshops, not in between.

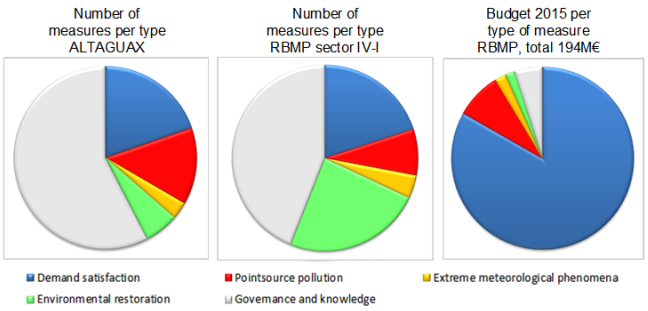
Discrepancies in plan preparation and petitions against the draft hydrological plan—bottom-up participatory process vs. official recording

Whereas the official diagnosis of water management challenges in the basin focused on demand satisfaction and infrastructure measures (disregarding some of the environmental and governance issues in the basin), the multistakeholder platform pushed much more for an integrated approach. This was the result of a series of debates between the vested water users and legal, economic, and environmental experts on the endangered sustainability of the ongoing model. Civil society would consequently be inclined to demand both administration and users of larger volumes of water to take responsibility. A qualitative analysis of the texts in both official plan documents and stakeholder workshop reports reveal these differences both in the identified problems and the proposed measures for the basin (see Table 1). To a certain extent, the preparatory document for the RBM plan (i.e., SWMI) also recognized the extent of governance issues, but the draft plan omitted a series of general problems applying to the basin (see Table 1). Arguments to include these problems were recorded during the workshops and officially communicated through the formulation of a series of petitions on the draft plan between workshops 3 and 4. (Based on analysis of significant water management issues (SWMI), the draft river basin management plan, and the final plan compared with workshop reports.)

The eventual measures that were recorded in the hydrological plan did represent the directives/indications from the working group to shift toward more governance strategies, yet the allocated budget reveals a continued focus on the "old paradigm" (Fig. 5). More than 80% of the available budget for 2015 still related to infrastructure measures for supply or demand, whereas programs for environmental restoration (2%), extreme meteorological phenomena (1.7%), governance (5%), and point source pollution (8%) received a relatively insignificant budget. A more detailed

analysis proved impossible due to lack of detailed budgeting on the specific measures.

Fig. 5. Distribution of (a) measures mentioned in the participatory workshops vs. (b) the official river basin management plan (RBMP, also referred to as hydrological plan, HP) and (c) distribution of total budget of 194 M€ for 2015 in sector IV-I per type of measure as recorded in the final hydrological plan.



Participation and user satisfaction

The number of participants in the workshops was between 21 and 25 in workshops 1, 2, and 3, whereas a total of 45 stakeholders participated in workshop 4, and the number dropped to 11 in the last workshop (see Fig. 4). High participation in workshop 4 was due to its strong mandate (as it was focusing on facilitating the formulation of petitions with a clear legal statute) and the geographical approximation to the less powerful, less motivated stakeholders. Toward the end, the planning process began to suffer severely from ongoing institutional reforms (reduced funding, staff cuts, and delays in the official planning) and subsequent chaos at the level of the authorities brought on by the global financial crisis starting in 2008, which particularly impacted the public budget in Spain. The initial optimism on available investments to improve water quality and restore degraded environments while securing water availability was gradually replaced by a widespread scepticism on the availability of proposed funding and a lack of trust in the continuity of planned measures. This is reflected in the lower participation in the last workshop and shows the difficulty of maintaining a productive and effective participatory process under unstable political circumstances and in the absence of a robust mandate and continued resources for the process.

After each workshop, participants were asked to evaluate the workshop on information base, content, and logistics and provide suggestions for improvement. In general terms, workshops were evaluated to be between satisfactory and very satisfactory (average score 4 out of 5). Stakeholders were generally satisfied with the exchange during the workshops and the added information provided by the SDSS and website. The most recurrent suggestions or remarks relate to the need to disseminate the information of the project to the general public and the absence of certain stakeholders such as entrepreneurs and some of the mayors.

Observations during workshops and indepth interviews

During the workshops, the need to decrease the politicization of the water management in the area was repeatedly expressed by several stakeholders from the regional administration, by the legal expert, and the major irrigator. All stakeholders confirmed that political tensions between the conservative municipalities and the socialist regional government were one of the reasons for delays in plan implementation.

Overall, the informed debates led to consensus building between the different stakeholders. For example, the cause of nitrate pollution was questioned by the greenhouse farmers blamed for it, but in light of data shown by university researchers and the administration, it was eventually accepted with inclusion of a note on return flows. (Greenhouse farmers argued that the greenhouse production system, with plants placed in controlled substrate and often even in impervious pots, creates little to no (potentially contaminating) return flow from irrigation.) The debates and subsequent outcomes were recorded in workshop reports that were circulated for comments before finalizing. An additional check on the sound building of a common ground was done by reviewing both problem analysis and potential measures over subsequent workshops in order to incorporate additional comments.

The indepth interviews revealed a consensus that the quality of information improved due to the project's approach, acknowledging the role of information flow, mediation, and the tool therein. Respondents also agreed that the approach had generated more transparency and trust; the latter at least among the nongovernmental stakeholders. The financial crisis and subsequent delays in workshops 4 and 5 were seen as detrimental to the engagement and trust that ALTAGUAX would/could seriously influence the official plan. Subsequently, respondents agreed it was a good choice to focus workshop 4 on generating official petitions. In terms of the tool, respondents highlighted the data transparency and visualization in maps, including Google Earth, as well as the indicator discussion as positive points. Nevertheless, several respondents pointed out that working with predetermined measures severely limited the functionality and usability of the tool. They suggested an option of generating measures and real-time evaluation by the tool to support debates, as an improvement.

DISCUSSION

The interplay between context, process, and outcomes in participatory planning, and of the ALTAGUAX project in particular, allows us to address the questions raised in the introduction. First, we analyze the contribution of the ALTAGUAX approach to the achievement of desired outcomes of stakeholders, planners, and the wider public (question 1). We then look at the generation of implementable decisions (question 2) by considering budget implications as well as alignment with innovative policy (question 3). In a third section, we discuss key lessons to move forward in design of participatory processes and tools (question 4). The discussion is structured around elements of the conceptual framework adapted from Newig (2007). At the end of each section, we discuss the specific role of the tool vs. participatory process and context.

Meeting the needs of stakeholders and planners?

The needs or interests of the stakeholders are to learn and be informed, to ensure that their accumulated knowledge of the system is taken into consideration by the planning authorities, and that their input will ultimately influence decisions. The needs and purpose of the planners are to achieve a plan based on current, relevant, and high quality data that is aligned with policy objectives and can be implemented within budget and without conflicts. In this section, we discuss the engagement process in terms of stakeholder composition, information quality, accountability, fairness, and mediation to create motivation, knowledge, transparency, trust, ownership, and empowerment. Furthermore, we look at the specific role of the tool.

We argue that, while building on existing social capital and relationships between researchers and stakeholders, embedding the tool in a mediated workshop process allowed for the formation of the previously described solid working group and enhanced the transparency, trust, and knowledge generation through information exchange. An indication thereof is the positive evaluation of the sessions and continued participation throughout the workshops (Fig. 4). Giving stakeholders a transparent and equally accessible platform on which to consult data, assuring clear workshop objectives, and giving feedback after workshops—online and through follow-up meetings if needed—as well as building on existing solid working relationships, were essential. Moreover, involving the stakeholders in the design of the open-source tool itself contributed to the trust in data and models used and accountability of the selection of measures.

The ALTAGUAX case confirms the observation of Huitema et al. (2009) that participation provides a valuable knowledge complement in a context of limited resources (time, budget, human capacity) to conduct detailed field work to inform effective planning and management. We further observed that, in a climate of trust, familiarizing the stakeholders with official planning procedures enables the realization that contributing to information exchange and offering lay system understanding are important to support the planning formulation, creating ownership and fuelling motivation. However, scholars (e.g., Cooke and Kothari 2001, Blaikie 2006) warn about the hijacking of the process by powerful players. In an open process, admitting to lack of data and weaknesses in the authorities' functioning entails a risk of creating opportunities for powerful stakeholders to "abuse" this by deliberately filtering information to increase their power status. In our case, this risk was exacerbated by the fact that powerful players, such as the larger irrigation association, were well represented in all workshops, whereas most of the smaller irrigators lacked skilled associates to counter this influence, partly due to their lack of resources and the loss of skilled labor to more lucrative jobs. However, hijacking of the process and data was largely avoided by the transparency of data and trust, aided on the one hand by the tool and on the other hand by the composition of the workgroup, including a broad spectrum of critical viewpoints as well as mediation skills. The presence of experts in hydrology, economy, ecology, and law who were independent of the administration and the powerful stakeholders mitigated the risk of hijacking on several occasions, resulting in increased fairness of the process. Expertise and mediation proved essential to balance vested users' power; stakeholders representing nonconsumptive uses needed to demonstrate indepth knowledge to be heard at the table, and in general, mediation by a skilled facilitator/mediator was needed to include the knowledge of less powerful stakeholders in the debates. In that sense, the workshops contributed to empowerment, as they provided a platform for inclusion of the marginalized. To maintain inclusion over the full course of the planning process, a flexible organization and extra effort were needed to address declining motivation of remote, smaller scale water users and less powerful stakeholders. Nevertheless, power relationships influenced the process as discussed below.

The tool contributes to empowerment through its equal access and multicriteria analysis module in which all stakeholders have an equal, transparent, yet anonymous vote. Transparency and discussion of data on a platform such as the web-based PGIS tool designed in this research proved essential to avoid deliberate acts of misinformation. More specifically, the explicit participatory process in the selection of indicators and their calculation (including the choice of data sources and extended debates considering "new" indicators such as environmental quality) was considered essential to generate ownership. However, the web-based PGIS tool also showed limitations. First, the uptake in between the workshops was limited, due in part to internet literacy, but mainly because the tool needs capacitation and deliberation. Second, even if the web-based PGIS tool has a multiscalar functionality that allows zooming in on specific local problems and, as such, appealing to stakeholder motivation that is driven by the territorial scale at which participation occurs (Huesker and Moss 2015), attendance at the workshops decreased. In our case, workshops had to be multiplied and focused on upstream water bodies to maintain engagement. Our observations therefore question the stand-alone potential of multiscalar functionalities of PGIS tools discussed by McCall and Dunn (2012) and of online functionalities in general to multiply information exchange and interaction. We observed that the tool needed to be accompanied by a deliberative process in order to reach its full potential, confirming the importance of face-to-face engagement highlighted by the EEA (2014). The quality of the engagement process largely depends on the representative composition and continuity of the working group. The latter (in our case) could only be achieved by continued intense networking and sustained contact through frequent meetings and follow-up at different territorial scales. Lastly, the ownership of tool outputs through codesign of indicators is limited by the flexibility or rigidity in calculations and underlying data. Theoretical flexibility of the ALTAGUAX tool was maximized by use of open-source software and a modular design (see Appendix 1) that allows easy inclusion of new indicators or calculation modules and a switch to different rendering plug-ins. However, tool flexibility proved limited in practice by the resources allocated to process requested changes. Apart from a need for design-driven flexibility, we observed that the use of the tool needs to be adapted to the unfolding process.

Contribution to implementable policy outcomes, democratization and alignment with the European Union Water Framework Directive?

Even though meeting the diverse and often contradictory needs of planners, stakeholders, and the general public remains ambitious, this process is generally better understood and

increasingly addressed by researchers and practitioners. More challenging, however, is the design of participatory processes so that they produce implementable and effective policy outcomes in a cost-efficient manner. In this section, we investigate what enables or disables participation from moving to implementation, in part through looking at financial commitment. We also explore to what extent the approach leads to improved democratization of decisions and their alignment with the EU WFD.

First, we discuss the uptake of the participation results or stakeholder preferences during the debate and in the RBM plan. Functionalities such as mind maps and simple voting in the first workshops, combined with a more complex voting system in the multicriteria analysis module of the web-based PGIS tool in the later workshops, provide transparency and accountability in terms of priorities indicated by the stakeholder group. It should logically follow that these preferences and priorities are also recorded in the resulting plan. When analyzing listed preferences (Table 1), we observe governance issues as the first priority, followed by groundwater overexploitation and selected measures aiming at a combination of supply and demand management while reaching out to other sectors (such as rural development through conservation of traditional practices). This seems to confirm the potential of participatory approaches to (1) generate implementable decisions and (2) lead to a more integrated planning, aligning decisions with the new water management paradigm embodied by the EU WFD (Voulvoulis et al. 2017). When considering the latter, we clearly observed a leverage effect by involvement of "new" stakeholder groups, outside of the vested, powerful interests. These stakeholders, often nonconsumptive users and ecologists with social and environmental goals, are more rapidly engaging with new WFD policy principles such as cost recovery and ecological status as they perceive it as an opportunity to effect change. In their discussion with open-minded and willing, yet resource-limited planning officers, they provided guidance and gave a certain momentum to the changes in the planning process. In addition to the previously discussed balancing of power struggles, this policy guidance is deemed crucial for WFD implementation (Söderberg 2016). Through social learning (Huitema et al. 2010, Selman et al. 2010, Hoverman et al. 2011), the ALTAGAUX approach contributed to more aligned decisions, at least in terms of the shift from infrastructure-based measures to governance measures including environmental objectives. The final uptake of the recommendations is however not clear, as several of the measures proposed by the ALTAGUAX group did not appear in the final plan (Table 1). A number of stakeholders mentioned that the "official truth" generated at the end of the participation processes (when producing the final recording in the official plan) was a product of power relationships manifesting themselves at that stage. This is further illustrated by the discrepancy between numbers of measures and allocated budget per category (Fig. 5*b*). It shows the limited influence the participation has had on the final planning outcome despite considerable time and resources invested.

We identify two issues faced by the present participatory planning process and supporting tool to enable implementation and policy alignment: (1) the importance of context, mandate, and political commitment (related to process and somehow exogenous to the tools) (e.g., Straton et al. 2011, Söderberg 2016); and (2) the importance of monitoring and evaluation to increase transparency and accountability (related to both process and tools).

Our experience identified the availability of economic information and budget allocation per measure as a major challenge to transparency and accountability. The limited information available to stakeholders was heavily criticized primarily by the experts and ecologists, but also by the farmers and municipalities, who argued that it was impossible to evaluate the cost efficiency of potential measures without this information, making the evaluation of measures inconclusive. (It is important to note here that cost effectiveness may have different meanings and entail different priorities for different stakeholders.) Nevertheless, the planning officers produced a RBM plan with budget per measure (1) that lack the necessary detail regarding timing and spatial distribution and (2) without disclosing the priorities or reasoning behind the allocation. The absence of a transparent discussion on budget allocation has proved to be a major challenge during this research and links to the issue of context and mandate of not only the participatory process itself, but also of the water administration coordinating it. Although given a coordinating role, the water administration has no executive or prohibitive mandate on the budgets that are allocated to the traditionally powerful ministries of public works and agriculture. This continued fragmentation of responsibilities and the weak interpretation of the coordinating role of the water administration undermine the democratic ruling aimed at by public participation and hamper the implementation of an ambitious policy with cross-sectoral implications, such as the EU WFD, confirming observations by Söderberg (2016). We further observed that the ongoing institutional reform strongly impacted the outcome of the participation exercise—between 2005 and 2009, the Andalusian water administration shifted from being a powerful singular water agency as a satellite of the environmental ministry under the socialist party PSOE to a delegation under the Ministry of Agriculture, Food and the Environment with the rise of the more conservative PPP party. This was exacerbated by the financial and social crisis. Whereas the water administration started the process with a strong mandate and political will, it gradually lost its leading role due to reduction of resources allocated to water authorities and the objectives of the new water paradigm in general. This discontinued mandate and lack of political will resulted in an incomplete voting using the multicriteria analysis tool in workshop 5. This adaptation of the last workshop rendered the results of this study to some extent inconclusive on the approach's democratic potential as well as on the specific role of the tool therein. The reason being that, in general, underlying conflicts and related power play between opposing sectors/stakeholders surface in these later steps of the planning process (Kallis et al. 2006, Proctor and Dreschler 2006). Not having concluded a full voting and negotiation in the last workshop left questions around challenges for the approach to contribute to a democratic distribution of power and social equity partially unanswered. This confirms the importance of recognizing the complexity of context and mandate (e.g., Huitema et al. 2009), as well as continuity in the participatory process.

In conclusion, we argue that the main challenge identified is the unclear mandate in a highly dynamic sociopolitical context, jeopardizing continuity and trust in the process and implementation of its outcomes. Context matters and is driven

by a series of unpredictable and not always controllable factors that influence the participatory process. An explicit recognition of the dynamic nature of context in understanding participatory processes is therefore needed.

Key lessons to move forward

The combination of tools and processes should be maintained and further explored, as the tools complement and enhance the democratic dialog (through improved knowledge base and creation of transparency, and potentially legitimacy and accountability) while the process provides the needed face-to-face interaction (for motivation, understanding, social equity) and can reduce the pitfalls discussed by Pfeffer et al. (2013).

This research identified important challenges related to (1) the implementation of the participatory process and (2) the limited uptake of the supporting tool outside of the facilitated workshop environment at the water-body scale. Introduction of tools does not reduce the amount of resources and time needed to implement a participatory process, nor reduce the attention needed for motivation, power imbalances, and political commitment. Furthermore, in this case, the tools were meant to facilitate the process by providing a reference frame (common understanding) and assisted memory but did not have the capacity to structure contextual dynamics. Our observations confirm the limits of intentional process structure design (Hare et al. 2003) and call for the consideration of the dynamic nature of context when analyzing the relationship between context, cooperation, and participatory tools as discussed by Basco-Carrera et al. (2017). Tools need to be flexible and their use adaptable to changing contextual dynamics if they are not to become redundant.

Flexibility can be partly achieved by focusing future design of the tools on increased flexibility in the evaluation of the measures. This can be done by improving the web platform itself (moving toward mobile devices) and/or by reducing the back-end calculations that need expert revision so as to allow stakeholders to interactively generate measures to be included in the multicriteria evaluation.

To improve implementation of participatory processes, we argue for improved methodologies to evaluate the contribution of such processes through analysis of the narratives that accompany the planning process as discussed in Cabello et al. (*in press*). We suggest a combination of process and intermediary outcome evaluation from the levels of evaluation proposed by Carr et al. (2012). This research revealed that a mere recording of preferences in the official documents will not lead to implementation thereof. We argue for future research on possibilities to align budgeting with preferences. Participatory processes could include a budget allocation step supported by tools, or at least there should be a clear link between priorization of problems and measures and the final budget. Work on participatory budgeting by Wampler (2007) can be explored to complement the European focus on cost-effective analysis currently induced by EU policy, which reportedly fails to capitalize on the benefits of participation (Wright and Fritch 2011).

In view of the persistent challenges of participatory planning processes and tools, further development and research should point at (1) improving the discussion on policy outcomes (reflected in the program of measures of the RBMP) by including economic/budget information and ensuring recording thereof in the outcomes of the participatory process; (2) creating mechanisms to monitor and evaluate to what extent preferences expressed in participatory processes are implemented; leading to (3) creating design processes and tools to monitor and evaluate policy effectiveness as a prerequisite for accountability. This could be facilitated by broadening the participatory indicator definition to include monitoring aspects, which could potentially lead to active participation of stakeholders in the monitoring itself. The degree to which the above will contribute to increased legitimacy and accountability will, however, strongly depend on the extent to which one can (4) achieve an improved mandate and ensure continued policy commitment.

CONCLUSION

This research presents an innovative approach to integrate processes and tools in support of participatory water resources planning. A web-based PGIS tool was codesigned with stakeholders and introduced in the planning process parallel to more qualitative discussions on the origin of problems and programs of measures in the basin. Observations from the case study on hydrological planning in a semiarid area in Europe suggest that the use of web and GIS support enhances information transparency and allows gradual knowledge of the system, with particular attention on participatory indicator definition and the possibility to visualize differences in opinions among stakeholders. The applied workshop approach proved successful in building up relationships, trust, and continuity in the multistakeholder platform. Although power plays remain present in the overall planning process, the composition of the group, professional facilitation, and anonymous voting facilitated by the tool contribute to social equity during the workshop debates.

Despite the clear contribution of this approach to the debates underlying the planning formulation, it proved limited in aligning the water management approach from a paradigm of maximizing water extraction to satisfy mainly agricultural demands in the short term to one that satisfies multiple demands, including ecological, for the long term introduced by new water policy. This was shown by the limited uptake of the measures proposed by the ALTAGUAX group in the final plan and the clear (at least budgetary) focus of that plan on demand satisfaction. We identified an unclear mandate, discontinuity, and absence of essential budget information as the main challenges to the participatory planning process. These challenges were exacerbated by the high stakes (dependence of the ecologically vulnerable basin on one strong agricultural sector) and the problematical context (political and financial crisis). This shows (1) participation without clear attention to the uneven stakes and a mandate to change them is doomed to fail, and (2) context matters.

Faced with a complex set of competing interests in a complex basin, tools are no more and no less than a framework that can provide a reference frame and historic memory for the participatory planning process. A participatory design process for the tool contributes to increased user trust in and more consensus over the knowledge base the tool provides. Nevertheless, not only do these tools require an active facilitator, their functionality and use needs to be flexible as they are more likely to follow, not guide, complex sociocultural dynamics of change.

The present case study shows that participatory planning should be based on a thorough recognition of the importance of the sociopolitical and economic context and an analysis of the political economic priorities and constraints and ecosystem complexities to address what enables or disables process and its implementation.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/9987

Acknowledgments:

The results presented here were produced as part of the ALTAGUAX project. Financial support from the Andalusian Water Agency (Ministry of Agriculture, Food & the Environment at the time of publication) and UNESCO-IHE is acknowledged. The authors would like to thank the two anonymous reviewers for their valuable feedback on the structure and content of the manuscript.

LITERATURE CITED

Aznar-Sanchez, J., E. Galdeano-Gomez, and J. Perez-Mesa. 2011. Intensive horticulture in Almería (Spain): a counterpoint to current european rural policy strategies. *Journal of Agrarian Change* 11(2):241–261. http://dx.doi.org/10.1111/j.1471-0366.2011.00301.x

Barnaud, C., and A. van Paassen. 2013. Equity, power games, and legitimacy: dilemmas of participatory natural resource management. *Ecology and Society* 18(2): 21. http://dx.doi.org/10.5751/ES-05459-180221

Barnes, M., J. Newman, and H. Sullivan. 2007. *Power, participation and political renewal. Case studies in public participation.* The Policy Press, University of Bristol, Bristol, UK.

Basco-Carrera L., A. Warren, E. van Beek, A. Jonoski, and A. Giardino. 2017. Collaborative modelling or participatory modelling? A framework for water resources management. *Environmental Modelling and Software* 91:95–110. http://dx.doi.org/10.1016/j.envsoft.2017.01.014

Beierle, T. C., and D. M. Konisky. 2001. What are we gaining from stakeholder involvement? Observations from environmental planning in the Great Lakes. *Environment and Planning C: Government and Policy* 19(4):515–527. http://dx.doi.org/10.1068/c5s

Berbel, J., and L. Mateos. 2014. Does investment in irrigation technology necessarily generate rebound effects? A simulation based on an agro-economic model. *Agricultural Systems* 128 (C):25–34. http://dx.doi.org/10.1016/j.agsy.2014.04.002

Blaikie P. 2006. Is small really beautiful? Community-based natural resource management in Malawi and Botswana. *World Development* 34(11):1942–1957. http://dx.doi.org/10.1016/j.worlddev.2005.11.023

Bosque Sendra, J. 2001. Planificación y gestión del territorio. De los SIG a los Sistemas de ayuda a la decisión espacial (SADE). *El Campo de las Ciencias y las Artes* 138:137–174.

Cabello, V., Z. Kovacic, and N. Van Cauwenbergh. In press. Unravelling narratives of water management: reflections on epistemic uncertainty in the first cycle of implementation of the Water Framework Directive in southern Spain. *Journal of Environmental Science and Policy*.

Carr, G., G. Blöschl, and D. P. Loucks. 2012. Evaluating participation in water resource management: a review. *Water Resources Research* 48: 11401. http://dx.doi.org/10.1029/2011WR011662

Cleaver, F. 1999. Paradoxes of participation: questioning participatory approaches to development. *Journal of International Development* 11:597–612 http://dx.doi.org/10.1002/(SICI)1099-1328(199906)11:4<597::AID-JID610>3.0.CO;2-Q

Cooke, B., and U. Kothari. 2001. *Participation: the new tyranny?* Zed Books, New York, New York, USA.

De Vente, J., M. S. Reed, L. C. Stringer, S. Valente, and J. Newig. 2016. How does the context and design of participatory decision making processes affect their outcomes? Evidence from sustainable land management in global drylands. *Ecology and Society* 21(2): 24. http://dx.doi.org/10.5751/ES-08053-210224

European Commission (EC). 2000. *Directive 2002/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for the Community action in the field of water policy.* Official Journal of the European Communities OJ L327, European Commission, Brussels, Belgium.

European Environmental Agency (EEA). 2014. *Public participation: contributing to better water management. Experiences from eight case studies across Europe.* Publications Office of the European Union, Brussels, Belgium.

Faysse, N. 2006. Troubles on the way: an analysis of the challenges faced by multi-stakeholder platforms. *Natural Resources Forum* 30:219–229. http://dx.doi.org/10.1111/j.1477-8947.2006.00112.x

Fekete, A. , M. Damm, and J. Birkmann. 2009. Scales as a challenge for vulnerability assessment. *Natural Hazards* 55:729–747. http://dx.doi.org/10.1007/s11069-009-9445-5

Frutas y Hortalizas de Almería (Fhalmeria). 2006. *Más del sesenta y cinco por ciento de la producción almeriense se exporta a países de todo el mundo.* Fhalmeria, El Ejido, Spain. [online] URL: https://www.fhalmeria.com/noticia-8461/mas-del-sesenta-y-cinco-por-ciento-de-la-produccion-almeriense-se-exporta-a-paises-de-todo-el-mundo

Hare, M. 2011. Forms of participatory modelling and its potential for widespread adoption in the water sector. *Environmental Policy and Governance* 21(6):386–402. http://dx.doi.org/10.1002/eet.590

Hare, M., R. A. Letcher, and A. J. Jakeman. 2003. Participatory modeling in natural resources management: a comparison of four case studies. *Integrated Assessment* 4(2):62–72.

Hoverman, S., H. Ross, T. Chan, and B. Powell. 2011. Social learning through participatory integrated catchment risk assessment in the Solomon Islands. *Ecology and Society* 16(2): 17. http://dx.doi.org/10.5751/ES-04036-160217

Huesker, F., and T. Moss. 2015. The politics of multi-scalar action in river basin management: implementing the EU Water Framework Directive (WFD). *Land Use Policy* 42:38–47. http://dx.doi.org/10.1016/j.landusepol.2014.07.003

Huitema, D., C. Cornelisse, and B. Ottow. 2010. Is the jury still out? Toward greater insight in policy learning in participatory decision processes-the case of Dutch citizens' juries on water management in the Rhine Basin. *Ecology and Society* 15(1): 16.

Huitema, D., E. Mostert, W. Egas, S. Moellenkamp, C. Pahl-Wostl, and R. Yalcin. 2009. Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. *Ecology and Society* 14(1): 26. http://dx.doi.org/10.5751/ES-02827-140126

Jonsson, A. 2005. Public participation in water resources management: stakeholder voices on degree, scale, potential, and methods in future water management. *Ambio* 34(7):495–500. http://dx.doi.org/10.1579/0044-7447-34.7.495

Junta de Andalucia, 2017. *Cartografia de Invernaderos en Almeria, Granada y Malaga. Año 2017.* Report prepared by the Consejeria de Agriculura, Pesca y Desarrollo Rural, Seville, Spain. [online] URL:

Kallis, G., N. Videira, P. Antunes, Â. Guimarães Pereira, C. L. Spash, H. Coccossis, S. Corral Quintana, L. del Moral, D. Hatzilacou, G. Lobo, A. Mexa, P. Paneque, B. Pedregal Mateos, and R. Santos. 2006, Participatory methods for water resources planning. *Environment and Planning C: Government and Policy* 24:215–234.

Karpouzoglou, T., Z. Zulkafli, S. Grainger, A. Dewulf, W. Buytaert, and D. Hannah. 2016. Environmental virtual observatories (EVOs): prospects for knowledge co-creation and resilience in the information age. *Environmental Sustainability* 18:40–48.

Lopez-Gunn, E. 2009. Agua para todos: a new regionalist hydraulic paradigm in Spain. *Water Alternatives* 2(3):370–394.

Lopez-Gunn E., M. Rica, and N. Van Cauwenbergh. 2012. Taming the groundwater chaos. Pages 227–239 *in* L. De Stefano and M. Ramón Llamas, editors. *Water, agriculture and the environment in Spain: can we square the circle?* CRC Press/ Balkema, Leiden, The Netherlands. [online] URL: https://www.fundacionbotin.org/89dguuytdfr276ed_uploads/Observatorio%20Tendencias/PUBLICACIONES/LIBROS%20SEM%20INTERN/water-agriculture-environment/capitulo18-wagriculture.pdf

Lopez-Gunn, E., P. Zorrilla, F. Prieto, and M. R. Llamas. 2012. Lost in translation? Efficiency in Spanish Agriculture. *Agricultural Water Management* 108:83–95. http://dx.doi.org/10.1016/j.agwat.2012.01.005

Lundgren, R. E., and A. H. McMakin. 2009. *Risk communication —a handbook for communicating environmental safety and health risks.* Wiley, Hoboken, New Jersey, USA.

Martin-Ortega, J. 2012. Economic prescriptions and policy applications in the implementation of the European Water Framework Directive. *Environmental Science and Policy* 24:83–91. http://dx.doi.org/10.1016/j.envsci.2012.06.002

McCall, M., and C. Dunn. 2012. Geo-information tools for participatory spatial planning: fulfilling the criteria for 'good' governance? *Geoforum* 43:81–94. http://dx.doi.org/10.1016/j.geoforum.2011.07.007

Mollinga, P. 2008. Water policy—water politics. Social engineering and strategic action in water sector reform. Pages 1–32 *in* W. Scheumann, S. Neubert, and M. Kipping, editors. Water politics and development cooperation: local power and global governance. Springer-Verlag, Berlin Heidelberg, Germany. http://dx.doi.org/10.1007/978-3-540-76707-7_1

Mostert, E. 2003. The challenge of public participation. *Water Policy* 5(2):179–197.

Mostert E., C. Pahl-Wostl, Y. Rees, B. Searle, D. Tàbara, and J. Tippett. 2007. Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins. *Ecology and Society* 12(1): 19. http://dx.doi.org/https://doi.org/10.5751/ES-01960-120119

Muro, M., and P. Jeffrey. 2008. A critical review of the theory and application of social learning in participatory natural resource management processes. *Journal of Environmental Planning and Management* 51(3):325–344. http://dx.doi.org/10.1080/09640560801977190

Newig, J, 2007. Does public participation in environmental decisions lead to improved environmental quality? Towards an analytical framework. *International Journal of Sustainability Communication* 1:51–71.

Page, B., and K. Bakker. 2005. Water governance and water users in a privatised water industry: participation in policy-making and in water services provision: a case study of England and Wales. *International Journal of Water* 3(1):38–60. http://dx.doi.org/10.1504/IJW.2005.007158

Parés M, Q. Brugué, J. Espluga, J. Miralles, and A. Ballester. 2015. The strengths and weaknesses of deliberation on river basin management planning: analysing the water framework directive implementation in Catalonia (Spain). *Environmental Policy and Governance* 25:97–110. http://dx.doi.org/10.1002/eet.1662

Pelling, M. 2007. Learning from others: the scope and challenges for participatory disaster risk assessment. *Disasters* 31(4):373–385. http://dx.doi.org/10.1111/j.1467-7717.2007.01014.x

Pfeffer, K., I. Baud, E. Denis, D. Scott, and J. Sydenstricker-Neto. 2013. Participatory spatial knowledge management tools. *Information, Communication and Society* 16(2):258–285. http://dx.doi.org/10.1080/1369118X.2012.687393

Proctor, W., and M. Drechsler. 2006. Deliberative multicriteria evaluation. *Environment and Planning C* 24:169–190. http://dx.doi.org/10.1068/c22s

Reed, M. S. 2008. Stakeholder participation for environmental management: a literature review. *Biological Conservation* 141 (10):2417–2431. http://dx.doi.org/10.1016/j.biocon.2008.07.014

Reed M. S., A. Graves, N. Dandy, H. Posthumus, K. Hubacek, J. Morris, C. Prell, C. H. Quinn, and L. C. Stringer. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management* 90 (5):1933–1949. http://dx.doi.org/10.1016/j.jenvman.2009.01.001

Refsgaard, K. 2006. Process-guided multicriteria anlaysis in wastewater planning. *Environment and Planning C: Government and Policy* 24:191–2013. http://dx.doi.org/https://doi.org/10.1068/c21s

Sanchez-Picon A., J. A. Aznar-Sanchez, and J. García-Latorre. 2011. Economic cycles and environmental crisis in arid southeastern Spain. A historical perspective. *Journal of Arid Environments* 75:1360–1367. http://dx.doi.org/10.1016/j.jaridenv.2010.12.014

Sandker, M., B. M. Campbell, M. Ruiz-Pérez, J. A. Sayer, R. Cowling, H. Kassa, and A. T. Knight. 2010. The role of participatory modeling in landscape approaches to reconcile conservation and development. *Ecology and Society* 15(2): 13. http://dx.doi.org/10.5751/ES-03400-150213

Sauri, D., and L. del Moral. 2001. Recent developments in Spanish water policy: alternatives and conflicts at the end of the hydraulic age. *Geoforum* 32:351–362. http://dx.doi.org/10.1016/S0016-7185(00)00048-8

Selman P., C. Carter, A. Lawrence, and C. Morgan. 2010. Re-connecting with a neglected river through imaginative engagement. *Ecology and Society* 15(3): 18. http://dx.doi.org/https://doi.org/10.5751/ES-03476-150318

Söderberg C. 2016. Complex governance structures and incoherent policies: implementing the EU water framework directive in Sweden. *Journal of Environmental Management* 183 (1):90–97. http://dx.doi.org/10.1016/j.jenvman.2016.08.040

Straton, A., S. Jackson, O. Marinoni, W. Proctor, and E. Woodward. 2011. Exploring and evaluating scenarios for a river catchment in northern Australia using scenario development, multicriteria analysis and a deliberative process as a tool for water planning. *Water Resources Management* 25:141–164. http://dx.doi.org/10.1007/s11269-010-9691-z

Swyngedouw, E. 2007. Technonatural revolutions—the scalar politics of Franco's hydro-social dream for Spain 1939–1975. *Transactions, Institute of British Geographers* 32(1):9–28. http://dx.doi.org/https://doi.org/10.1111/j.1475-5661.2007.00233.x

Swyngedouw, E. 2013. Into the sea: desalination as hydro-social fix in Spain. *Annals of the Association of American Geographers* 103(2):261–270. http://dx.doi.org/10.1080/00045608.2013.754688

Tan, P., K. Bowmer, and J. Mackenzie. 2012. Deliberative tools for meeting the challenges of water planning in Australia. *Journal of Hydrology* 474:2–10. http://dx.doi.org/10.1016/j.jhydrol.2012.02.032

United Nations. 1993. *Agenda 21: the United Nations programme of action from Rio.* United Nations, New York, New York, USA.

United Nations Economic Commission for Europe (UNECE). 1998. *Convention on access to information, public participation in decision-making and access to justice in environmental matters.* Aahrus, Denmark, 25 June 1998. [Online] URL: http://www.unece.org/fileadmin/DAM/env/pp/documents/cep43e.pdf

Van Cauwenbergh, N., and S. Idllalene, 2012. Tapping into Al-Andaluz resources: opportunities and challenges for investment in Morocco. Pages 193–206 *in* J. A. Allan, M. Keulertz, S. Sojamo, and J. Warner, editors. *Handbook of land and water grabs in Africa. Foreign direct investment and food and water security.* Routledge, London, UK.

Van Cauwenbergh, N., D. Pinte, A. Tilmant, I. Frances, A. Pulido-Bosch, and M. Vanclooster. 2008. Multi-objective, multiple participant decision support for water management in the Andarax catchment, Almeria. *Journal of Environmental Geology* 54 (3):479–489. http://dx.doi.org/10.1007/s00254-007-0847-y

von Korff, Y., K. A. Daniell, A. Moellenkamp, P. Bots, and R. M. Bijlsma. 2012. Implementing participatory water management: recent advances in theory, practice, and evaluation. *Ecology and Society* 17(1): 30. http://dx.doi.org/10.5751/ES-04733-170130

Voulvoulis N, K. Arpon, and T. Giakoumis. 2017. The EU Water Framework Directive: from great expectations to problems with implementation. *Science of the Total Environment* 575:358–366. http://dx.doi.org/10.1016/j.scitotenv.2016.09.228

Wampler, B. 2007. *Participatory budgeting in Brazil: contestation, cooperation, and accountability.* Penn State University Press, University Park, Pennsylvania, USA.

Warner, J. 2006. More sustainable participation? Multi-stakeholder platforms for integrated catchment management. *International Journal of Water Resources Development* 22(1):15–35. http://dx.doi.org/10.1080/07900620500404992

Webler, T., and S. Tuler. 2001. Public participation in watershed management planning. *Human Ecology Review* 8(2):29–39.

Wright, S., and O. Fritch. 2011. Operationalising active involvement in the EU Water Framework Directive: why, when and how? *Ecological Economics* 70:2268–2274. http://dx.doi.org/10.1016/j.ecolecon.2011.07.023

Appendix 1 Spatial Decision Support System – participatory design

The spatial decision support system (SDSS) is embedded in a webpage and has 3 principal components (figure A1.1): (1) a management system for the spatial database, (2) a mathematical model to create water management alternatives quantified by a set of indicators, (3) an evaluation tool based on multicriteria evaluation.

The ensemble has a final user interface linked to maps and is accessible through the internet. Whereas the general architecture of the tool (using MCA and spatially distributed hydrological and socio-economic modelling) was predefined by the researchers, the stakeholders co-designed the tool in following specific aspects: (1) the SDSS web interface (with general socio-economic and legal information on the basin, calendar and blog) and type of maps used (google earth basin diagnosis and p-mapper indicator queries), (2) the selection and calculation procedures for the socio-economic and environmental indicators, (3) the definition and parameterization of alternatives and scenarios used in the comparative MCA analysis for planning and (4) the visualization options of individual and group voting on water management alternatives, including individual and group ranking of alternatives as well as a variance map displaying the differences in opinions between stakeholders and indicators. The participatory design and inclusion of stakeholders' opinions was achieved both through in-depth interviews and the debates in the workshops, incorporating modifications following stakeholder needs. This ensures that the stakeholders are involved in all phases of the hydrological planning, including the underlying information sources and design of tools used.

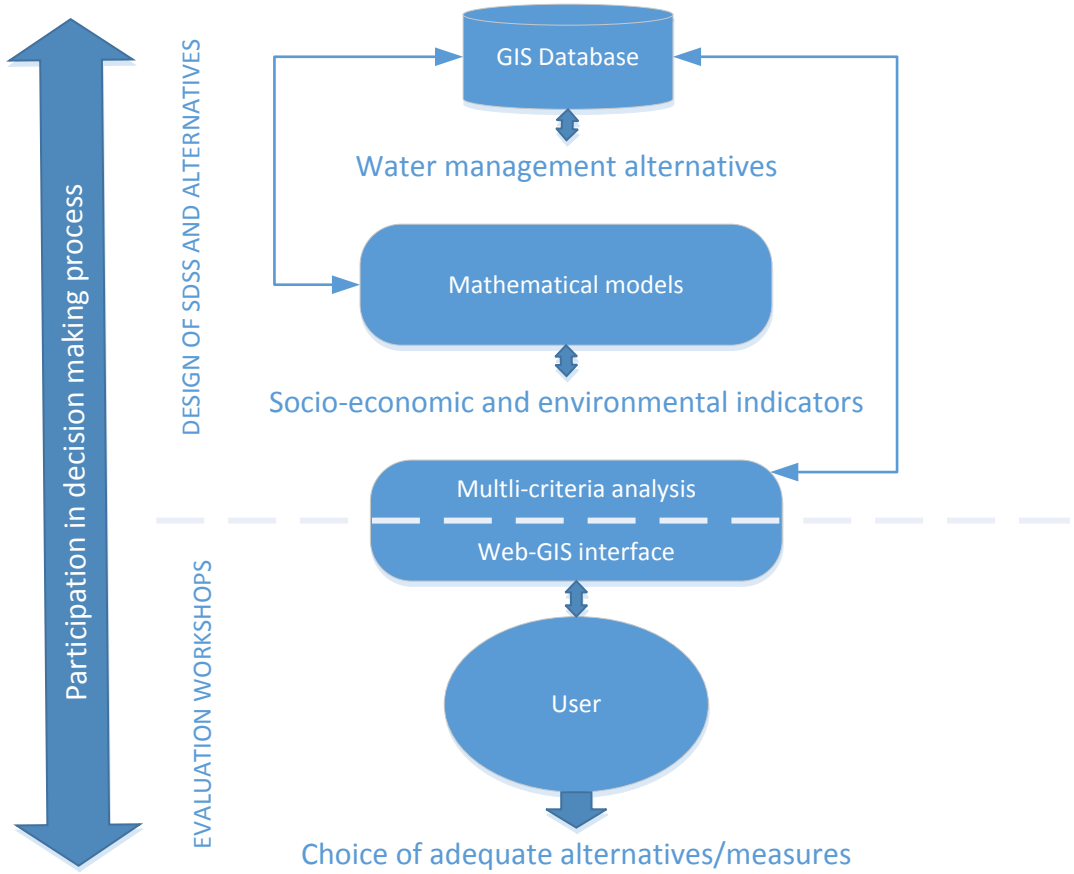


Figure A1.1: Architecture of the spatial decision support system (SDSS), with (1) a spatial database manager, (2) a scenario and alternatives generator and (3) a user interface embedded in a web 2.0 environment

To increase accessibility for the administration and the general public, the SDSS tool and the supporting webpage were developed in an "open" source philosophy and according to the guidelines of the EU INSPIRE[1] directive. This means that the web environment and all its embedded applications use free software programmed with open codes and facilitate data exchange. This allows it to be updated and improved at any time thereby facilitating its access by the general public through internet.

The ALTAGUAX multicriteria analysis tool is based on a subset of 15 indicators (5 economic, 5 social and 5 environmental) that were selected through a participatory priorization process out of an extended list of 46 indicators, themselves based on literature review of indicators for (ground)water management. Figure A1.2 shows the extended list of indicators and selected indicators highlighted in grey. Calculation procedures are explained in the web application altaguax.unesco-ihe.org and further detailed in Altaguax project documents (available upon request). In addition to these indicators, the group requested to include a “new” indicator on environmental quality (in addition or replacing the more restricted indicator on “groundwater quality”). Discussions on the quantification protocol for such an indicator were inconclusive.

ENVIRONMENTAL
Groundwater quality (GQ)
Salinization of aquifer
Relative quantity of depurated wastewater
Treatment need for consumption of groundwater
Reuse of depurated wastewater (WR)
Groundwater depletion (GD)
Total extraction of aquifer in function of estimated recharge (TAR)
Quantity of groundwater resources available per user
Total exploitatoin of groundwater resources
Variation in surface water fluxes
Terrain value
Evolution of protected natural areas (%increase/ decrease)
Urban development increase
Quantity of internal renewable resources* in relation to groundwater
Volumen of groundwater pumped in relation to non-conventional resources*
Dependency of agricultural population on groundwater (DAG)
Dependency of tourism on groundwater
Groundwater pumped in function of total amount of water for human consumption

ECONOMIC
Distribution efficiency (DE)
Irrigation efficiency (IE)
Pumping costs (Kwh or /m³)
Transfer costs (Kwh or /m³) (CC)
Decontamination costs
Recharge costs for recuperaton of aquifer (Kwh/ m³)
Total energy consumption (Kwh/m³) (TEC)
Percentage of subsidies on water price
Price of water in relation to operation and maintenance costs (WPC)
Water productivity (/m³)
Water productivity (EAJ/m³)

SOCIAL
Income per capita
Income per sector
Consumption power in relation to water price
Risk of not being able to supply water for human consumption (RU)
Risk of not being able to supply water for irrigation (RA)
Rate of accesability to drinking water (AC)
Rate of human migration
Percentage of tourists
Employment created (EAJ/m³)
Employment rate
Implication of stakeholders (IS)
Private water uses in relation to uses with a public concession
Institutional transparency
Possibility to influence decision making
Information distributed by the administration competent in water issues
% private water enterprises in relation to public enterprises
Control performed by competent administration (quality and quantity) (IC)

* desalinated and depurated wastewater /
EAJ = Equivalent of 1 person labor day

Figure A1.2: List of indicators based on literature presented to the multi stakeholder working group and highlighted selected indicators (5 environmental, 5 social and 5 economic).

[1] Infrastructure for Spatial Information in the European Community, 2007