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Towards an art and science of decision aiding for water management and planning: a participatory modelling process

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Abstract: Planning and management of water resources are faced with increasingly high levels of complexity, uncertainty and conflict. Traditional technical and top-down management strategies have proved inadequate, forcing a move to more "integrated" forms of management, planning and decision making that can include stakeholders and communities, as well as technical experts and policy makers. These integrated forms of management require not only good technical or scientific ability, but a range of "art-like" skills including communication, creativity and the capacity to acknowledge and integrate diverse points of view. However, processes designed to aid such inter-organisational or multi-stakeholder decision-making are rare and in need of investigation. This paper proposes a process of "participatory modelling" using a series of semi-structured collective decision cycles that can aid decisions involving multiple stakeholders in water management and planning. The participatory modelling process outlined in this paper is designed to capture and integrate both tacit and explicit knowledge from stakeholders, right from the problem identification phase through to the final decision making, implementation and ongoing monitoring and evaluation. A brief idealised example of the participatory modelling process testing in Montpellier, France, is highlighted, as well as further questions and identified priority research areas.

Keywords: Decision aiding, participatory modelling, water management, planning, multi-stakeholder.

1. INTRODUCTION

Planning and management of water resources and their associated decision making processes are often difficult due to high levels of uncertainty, complexity and conflict. Under these conditions, "traditional" methods of water management and planning are rarely sufficient [Gleick, 2000]. In complex water management and planning contexts, it is unusual that one institution possesses all of the relevant knowledge and is in control of all the resources required to successfully implement its own decisions. This means that water managers are obliged to work with other institutions, stakeholders and the general public to create more acceptable plans and to implement management solutions [Loucks, 1998]. Working with a variety of stakeholders or other "actors" requires not only scientific prowess but a number of 'art' related skills such as creativity, communication and the ability to identify, integrate, align or trade-off between multiple viewpoints. In addition to these diverse competencies, knowledge related to group decision and planning processes may also be vital for decision aiding.

With all of these challenges, it will be argued in this paper that the development of "decision aiding" methodologies, designed to capture these competencies, would be of great benefit to the multi-stakeholder, inter-organisational water management and planning processes that are currently being embarked upon around the world.

2. DECISION AIDING FOR WATER MANANAGEMENT AND PLANNING

2.1 What is decision aiding?

Decision aiding is common in everyday life where people help others to formulate and make decisions. It has been studied in a number of disciplines including operational research or management science, law and psychotherapy [Tsoukiàs, 2005]. In this paper it is the operational research (OR) vision of decision aiding that is examined. From an OR viewpoint, decision aiding typically refers to the process where a "decision analyst" aids a "client" (the decision maker) to formulate and analyse his or her "decision problem" in a structured way before a decision is made. The majority of OR decision aiding research has focussed on either one-to-one (analyst-client) or intra-organisational group decision aiding, rather than on the inter-organisational and multi-stakeholder group decision aiding situations that are common in the water sector. One sub-section of OR known as "problem structuring" is perhaps the best exception to this general trend, with frameworks such as the "strategic choice approach" [Friend and Hickling, 1987] and the "soft-systems methodology" [Checkland, 1981] being used for complex and uncertain decision aiding in the multi-organisational context. Such frameworks emphasise the importance of the problem identification or formulation phases of a decision process when dealing with "unstructured" or "messy" problems; phases that are typically taken as "fixed" or "given" in traditional decision aiding and technical management approaches for "structured" decision problems.

Decision aiding for messy problems focuses on providing "decision analysts" with methodological aids that will allow them to facilitate a group in a transparent manner to structure and exchange views from the problem and objectives identification to final recommendations or "choices". This process occurs in an "interaction space" [Ostanello and Tsoukiàs, 2003], where the collective construction of the participants' representations of the problem can be considered as a "meta-object" or "model" that can form the basis for further collective discussion and decision making. Interactions between the various process participants will be governed by rules that may only exist within the "interaction space". However, in inter-organisational groups, unlike in groups that share the same organisational background and accountability structures, there will be other outside factors, interests or rules which will affect the ability of each participant to agree on decisions. Participants may only have limited power to enter into commitments on behalf of their organisations, making such a working group "multi-accountable" and less similar to a traditional "team-like" group [Friend, 1993]. In this context, it is likely that the "interaction space" of the decision processes will not be limited to just a working group which meets, but rather be theoretically stretched to include the external interactions and negotiations that are likely to occur between organisations at different managerial levels. The decision aiding processes used in these situations must therefore be sensitive and applicable to these more complex environments.

2.2 Towards an art and science of decision aiding

To provide an integrated approach for aiding water management and planning decisions, it is believed that the best practices and ways of thinking from both the arts and the sciences which are applicable to the management and planning of human-environment problems must be harnessed [Ackoff, 2001, Foley and Daniell, 2002, Loucks, 1998, Gleick, 2000], as well as the recent experiences and techniques used in the field of OR decision aiding. This means that methodological aids must be designed to encourage the value of both subjective and objective viewpoints and to draw upon both the tacit and explicit knowledge of the involved "actors" [Nonaka and Takeuchi, 1995], as outlined in Figure 1. An emphasis on time-dependent processes such as change mechanisms, learning, strategy, development and monitoring is also vital, as decisions taken may have long ranging effects in time and space.

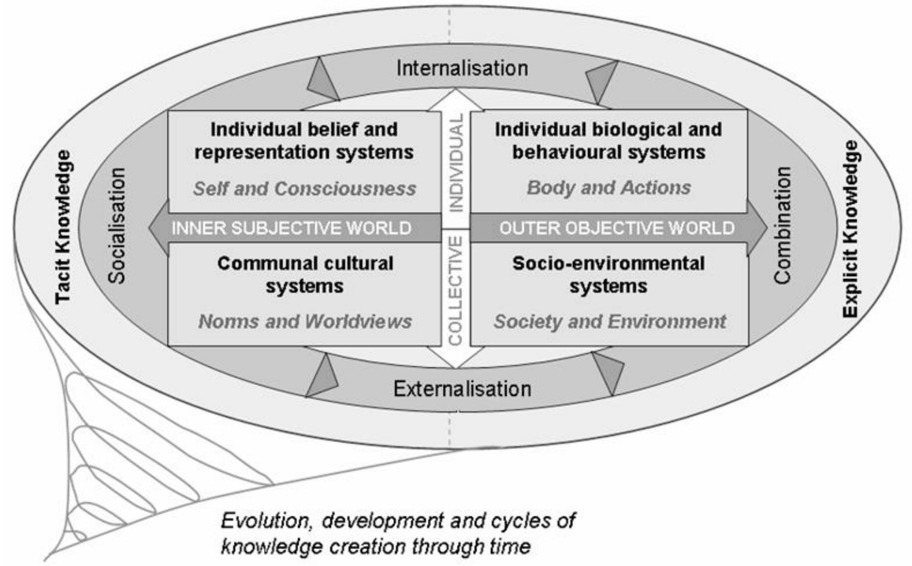

Figure 1. Decision aiding methodology considerations for water planning and management

On the "art" side, important aspects to be considered include developing the capacity to create emotional and communication links [Tolstoy, 1930], developing creativity, empathy and intuitive thought processes, and allowing reflection and interpretation. On the "science" side, aspects of rational and logical enquiry should be preserved, as well as explicit bodies of scientific knowledge based on the principles of refutability [Popper, 1959] or fallabilism [Peirce, 1958] relevant to the problems being studied. These may include mathematical modelling techniques or other forms of logical analysis. Both the "art" and the "science" are not necessarily separate, but rather complementary, parts of a whole or holon [Koestler, 1967]. Both provide important bases for learning cycles and innovation in inter-organisational or multi-stakeholder water sector applications. A conceptualisation of the necessary aspects when developing an "integrated" methodology for decision aiding is highlighted in Figure 1. These include both the individual and collective, and the internal (subjective) and external (objective) viewpoints (adapted from Wilbur [2000]), as well as the spiralic process of knowledge production and innovation outlined by Nonaka and Takeuchi [1995]. This knowledge production or learning cycle outlines the processes that occur when one type of knowledge [Schumacher, 1977] is transformed into another.

3. USING PARTICIPATORY MODELLING TO AID DECISIONS

One potential way of harnessing and encouraging consideration and development of the areas in Figure 1 is to create a "participatory modelling" framework which can be used as an integrated decision aiding process. Participatory modelling is a process that allows a number of different points of view to be explicitly represented and collectively reflected upon by a group of stakeholders before a collective decision is made [Ferrand, 1997]. This is unlike traditional modelling used to aid decisions that is carried out by one person or organisation and which may or may not include information from stakeholders. Participatory modelling, also known as "shared vision modeling" [Palmer et al., 1993], "group model building" [Vennix, 1996], and "mediated modeling" [van den Belt, 2004] is not a new concept in water management and planning, but has many examples evident around the world (e.g. Hare et al. [2003] and Korfmacher [2001]). However, the intent of these examples is rarely specified as a "decision aiding process", but rather: to build a better model, to resolve conflicts, to understand the situation under examination better, or a variety of other objectives [Daniell et al., 2006].

Before commencing a participatory modelling process as an inter-organisational decision aiding exercise, it is likely that there will be some preliminary interaction between the "decision analyst" and one or more of the stakeholders. During this preliminary interaction, an agreement may be made to help these stakeholders to structure and manage a particular issue under certain rules of engagement. In this process the decision analyst needs to be legitimated in his or her capacity to engage the participants. Other stakeholders from different institutions who are thought to have interests in the issue can then be invited to join in the participatory modelling and decision aiding process which is outlined in the following Stages 1 to 4. The process is based on Tsoukiàs [2005] but specifically readapted for the inter-organisational case. It is noted that between each of the stages there is likely to be feedback to other stages (or switching between them), as highlighted in the Strategic Choice Approach [Friend and Hickling, 1987].

3.1 Stage 1: Representing the problem situation

The first stage of the participatory modelling process for decision aiding is the definition of an "inter-organisational network" [Benson, 1975] around a problem of interest. This requires answers to questions such as:
- Who has a problem or issue to resolve?
- Why is this considered to be a problem?
- Is this a problem for anyone else?
- Who has the resources to manage this problem?
- Who makes the final decision?
- Who else will be affected by the decision?

This means defining a representation of the problem situation ([Tsoukiàs, 2005] and [Ostenello and Tsoukiàs, 1993]) that is based on:
- A set of "actors" who are the participants and stakeholders: individuals or organisations
- A set of "objects", such as concerns, interests or stakes, for each of the identified actors
- A set of "resources" or either physical or abstract factors linked to the actors and objects. These resources may be either currently available or unavailable to the actors.

Mapping exercises, individual reflection and collective discussion and analysis relating to the links between these three sets will result in the first collective "model" (whether entirely explicit or not) for the participatory modelling process.

3.2 Stage 2: Formulation of the problem and objectives

The aim of the second stage of the participatory modelling process is to formalise which parts of the problem situation are to be focussed on, and what decisions will need to be made at the end of the process. This means that communal objectives have to be decided on, and the following formulated:

- A set of "problem statements" which require decisions. In the case of developing water plans and management strategies, it is likely that more than one problem area will be addressed.
- A matrix of potential "actions" which is a set of actions that each actor could undertake relative to the set of problem statements.
- A matrix of potential "points of view" with which each actor will observe, evaluate, analyse and compare the set of actions.

This stage varies slightly from the decision aiding model described in Tsoukiàs [2005], due to the need in the inter-organisational context of water management and planning to consider concurrently the problems, potential actions and points of view of more than one actor. Stage 1 and Stage 2 should provide a good opportunity for learning and knowledge production based on the analysis and integration of other actors' views, incorporating many areas of Figure 1.

3.3 Stage 3: Model exploration and options evaluation

Traditional decision aiding for water management and planning typically starts at this stage, where the problem formulation is taken as "given", and the focus is predominately on the socio-environmental systems box in Figure 1. Based on the previous stages of representing and formulating the problem and objectives, collective decisions need to be taken on:

- Which alternative sets of actions are to be evaluated as potential options for decisions. These alternatives or scenarios will help to dictate the relations and functions required to be considered in model/s if there is more than one problem statement.
- The set of dimensions, attributes or indicators and their corresponding scales under which the alternatives will be described or measured (refer to Tsoukiàs [2005] for further description).
- The matrix of criteria against which the alternatives are evaluated, to take into account the actors' preferences.
- The matrix of uncertainties related to the dimension set and criteria matrix.
- A set of operators which allows the synthesis and manipulation of the above information to aid decision making.

Most commonly used modelling methods in water management and planning, whether qualitative of quantitative, could be described in terms of some of the elements described above. By the end of this stage, the "model" or "models" required to explore and allow the option evaluation will have been constructed and used by the participants.

3.4 Stage 4: Final recommendations

The final stage of the process may take place after a number of feedback loops or iterations through the other stages. This stage is to make choices about the final alternatives, decisions or a set of "final recommendations", to respond to the set of "problem statements" defined in Stage 2. When evaluating these final recommendations and the methods used to obtain them, a number of questions should be asked about their validity [Landry et al., 1983], and legitimacy [Landry et al., 1996]. Furthermore, issues such as how these decisions are going to be published, distributed, implemented and used should be considered, as well as the participants' and others' views of the success of the process and its outcomes.

3.5 Monitoring and evaluation

Continuous monitoring and evaluation can be carried out through the participatory modelling process as a part of each of the stages, as well as after the final stage. Monitoring and evaluation procedures can have a number of aims, including: determining whether objectives for the process are achieved; encouraging individual reflection; early identification of process problems or inefficiencies so adjustments can be made; and identification of what the process achieved, whether implementation of the final recommendations has occurred, and whether the results are acceptable. Depending on the specific aims of the decision aiding process, the evaluation process may be participatory or externally audited and use a range of methods from individual questionnaires, interviews, recording of workshop work (in written, audio or video format) to group debriefing sessions.

4. PRELIMINARY PROCESS TESTING

The proposed participatory modelling framework for decision aiding in the water sector has yet to be validated, especially for the inter-organisational context. Preliminary examination of the components of a participatory modelling process for the water sector was carried out in a test with a group of students in Montpellier, France. The test involved a series of seven three-hour workshops over a period from mid-October to mid-November 2005 with a group of 4 male and 5 female university students aged between 18 and 35. The students had diverse academic backgrounds and were recruited for the "research" project through advertisements in the universities around Montpellier. They were each paid a small amount of money to cover their attendance costs.

A number of qualitative and quantitative methods were then chosen in an attempt to maximise knowledge production, as outlined in Figure 1 and used to explore the elements outlined in the process of Section 3 for an abstract problem of water management at three spatial scales: the students' lives, local neighbourhood, and region or water basin. These methods included: cognitive mapping of the problem situation (Stage 1); a variant of Eden and Ackermann's [2001] "Oval Mapping Technique" for the problem and objectives formulation (Stage 2); UML (Unified Modeling Language™) conceptual modelling for an Excel spreadsheet model which was the basis of a role playing game for scenario exploration (Stage 3); and periods of debate and individual reflection for the final management decisions (Stage 4). Unfortunately, due to time constraints, only individual final recommendations on actions, and not collective ones, were completed. Due to the exploratory nature of the test, extensive evaluation was carried out through the process, including 15 questionnaires for the participants (with a range of closed and open questions that examined different areas of Figure 1 and external, normative, cognitive, operational, relational and equity, "ENCORE", elements [Le Bars and Ferrand, 2004]). These questionnaires explored the context, objectives, process and results of the test. Audio and video recordings also aided process evaluation.

4.1 Test Results and Emergent Issues

One unexpected result from the test was that "happiness" was the major water sector objective for the participants. The emergence of such an unconventional objective (from a technical point of view) is thought to be a good example of externalisation (the conversion of tacit to explicit knowledge), as shown in Figure 1. Such an outcome shows the potential for new integrated methods of decision aiding to examine problems from different perspectives. Other results included positive opinions of its general educational value, and that the highest levels of creativity and learning were found to have occurred in the problem structuring stages.
Issues requiring further investigation include:

- What levels of model and process complexity are required to adequately aid decision making from both the analyst's and the "clients'" points of view?
- Is the use of multiple methods an advantage or detriment to participant interest, learning, and cognitive load levels?
- How and when should external information and expertise be included in the process?

4.2 Future Research Questions

This research into the use of participatory modelling as a decision aiding process for inter-organisational or multi-stakeholder water management and planning is only in its preliminary phases. In order to further examine some of the hypotheses outlined in this paper, the processes need to be trialled and evaluated in real water management and planning situations. In this field, many research questions remain largely unstudied (in addition to those in Section 4.1), including:

- how decision making in inter-organisational or multi-stakeholder groups can be aided.
- what types of inter-organisational structures can aid creative, innovative and effective decision making.
- how "decision analysts" can be specifically trained with the necessary technical, relational and procedural capacities and can gain and maintain legitimate roles [Huxham, 1991] in water management and planning processes.

Finally, the time costs of the participatory modelling, and monitoring and evaluation processes, appear large. For organisations to invest in such procedures it must be demonstrated that the returns and outcomes from decisions arising from these processes exceed those made under traditional top-down processes.

5. CONCLUSIONS AND FUTURE RESEARCH QUESTIONS

To help mitigate complex problems in water management and planning processes, this paper has suggested that specifically trained "decision analysts" with a combination of "art and science" type skills could provide decision aiding services (targeted facilitation and analysis) to multi-stakeholder and inter-organisational groups. This could be achieved through processes such as the outlined four stage participatory modelling process, inspired from operational research decision aiding literature. This process has so far been tested through its application to an idealised example of water management in Montpellier, France. Such a process emphasises the importance of the problem structuring (the first two stages: "problem situation" and "formulation of problem and objectives"), something which tends to be treated as "given" or a trivial issue in traditional water management and planning. A number of further priority research areas were identified from the test, and further applications of the participatory modelling process for decision aiding in real, complex water planning are planned for the future. It is hoped that further study will help to validate the hypothesis that such processes could lead to more transparent, politically legitimate and scientifically valid decisions which could encourage higher levels of social acceptance and adoption.

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