Journal of Hydrology 519 (2014) 2515–2526

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Critical multi-level governance issues of integrated modelling: An example of low-water management in the Adour-Garonne basin (France)

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ARTICLE INFO

Article history:
Available online 5 October 2014

Keywords:
Multi-level governance
Integrated modelling
Collective choice arena
Decision-making
Scenario
Low-water management

SUMMARY

This paper presents the experience gained related to the development of an integrated simulation model of water policy. Within this context, we analyze particular difficulties raised by the inclusion of multi-level governance that assigns the responsibility of individual or collective decision-making to a variety of actors, regarding measures of which the implementation has significant effects toward the sustainability of socio-hydrosystems. Multi-level governance procedures are compared with the potential of model-based impact assessment. Our discussion is illustrated on the basis of the exploitation of the multi-agent platform MAELIA dedicated to the simulation of social, economic and environmental impacts of low-water management in a context of climate and regulatory changes. We focus on three major decision-making processes occurring in the Adour-Garonne basin, France: (i) the participatory development of the *Master Scheme for Water Planning and Management* (SDAGE) under the auspices of the Water Agency; (ii) the publication of water use restrictions in situations of water scarcity; and (iii) the determination of the abstraction volumes for irrigation and their allocation. The MAELIA platform explicitly takes into account the mode of decision-making when it is framed by a procedure set beforehand, focusing on the actors' participation and on the nature and parameters of the measures to be implemented. It is observed that in some water organizations decision-making follows patterns that can be represented as rule-based actions triggered by thresholds of resource states. When decisions are resulting from individual choice, endowing virtual agents with bounded rationality allows us to reproduce (*in silico*) their behavior and decisions in a reliable way. However, the negotiation processes taking place during the period of time simulated by the models in arenas of collective choices are not all reproducible. Outcomes of some collective decisions are very little or not at all predictable. The development and simulation of *a priori* policy scenarios capturing the most plausible or interesting outcomes of such collective decisions on measures for low-water management allows these difficulties to be overcome. The building of these kind of scenarios requires close collaboration between researchers and stakeholders involved in arenas of collective choice, and implies the integration of the production of model and the analysis of scenarios as one component of the polycentric political process of water management.

1. Introduction

Current water governance practices are challenged by a growing number of pressures suffered by socio-hydrosystems. Among these, we could point out: (a) current and potential impacts of climate change on the availability and accessibility of water resources (Arnell, 2004; Bates et al., 2008; Frederick 2001; Vörösmarty et al., 2000); (b) impacts of land use and land use changes on the water

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http://dx.doi.org/10.1016/j.jhydrol.2014.09.043
0022-1694/

cycle (Bhaduri et al., 2000; Elfert and Bormann, 2010; Hulse et al., 2004; IAASTD, 2009; Narcy, 2004); (c) human pressure, especially when dealing with increased water withdrawals for competing uses (Berndes, 2002; Murray-Hudson et al., 2006; Rosenzweig et al., 2004; Strzepek and Boehlert, 2010; Weiß et al., 2009); (d) implementation of public policies for protection or restoration of aquatic ecosystems (Haasnoot et al., 2011); and (e) the emergence and strengthening of participatory modes of management of public goods (Huitema et al., 2009). Even if climate change is a key driver in the availability of water resources, in some regions, socio-demographic, economic or technological changes can have a larger effect (Vörösmarty et al., 2000; Strzepek and Boehlert, 2010; Moss et al., 2010). With the increased risk of drought and water shortage, the development of structural measures used to support low-water management has grown in recent decades.

To design and implement water policy, demands for integrated and adaptive water resource management are progressively raised (Engle et al., 2011; Pahl-Wostl, 2007). Integrated modelling can simultaneously take into account most of the dimensions related to the issues of resource management (Jakeman et al., 2006). Integrated models that simulate the quantitative aspects of water system dynamics can be implemented as decision-support tools for policy building and managing natural resources within river basins by assessing various societal, hydrological and environmental effects of different scenario-based alternatives (Alcamo et al., 2000; Mahmoud et al., 2009; March et al., 2012). However, the modelling of water management presents a series of difficulties, especially related to the understanding and formalization of the decision-making process in multi-level governance systems (Pahl-Wostl et al., 2010). Following the pioneering analysis of Rittel and Webber (1973) concerning "*wicked problems*" of planning and governance in open social systems, we adopt a critical posture in our analysis and modelling practices as they deal with complex issues involving high stakes, with a high degree of uncertainty and with diverging perspectives on values and facts (Funtowicz and Ravetz, 1993).

With this in mind, the goal of this paper is to tackle the challenges of integrating various kinds of decision-making processes related to multi-level governance in water management modelling. As a starting point (Section 2), the organization of multi-level governance for low-water management in France is described, using the Adour-Garonne basin (South-West of France) as a case study. In Section 3 we discuss the potential of integrated modelling as means to deal with water management issues. Key studies based on modelling performed in the Adour-Garonne basin are briefly introduced and the modelling of two contrasting types of decisions is illustrated: (a) decisions that are akin to actions based on rules; and (b) decisions that involve bounded rationality of virtual agents. Section 4 highlights the importance of the negotiation processes occurring within collective-choice arenas in the effectiveness of water management in France. Then, we discuss critical issues and limits of integrated modelling to represent the collective decision-making processes induced by multi-level governance. Next, in Section 5, we describe how to deal with these limits, endorsing the use of policy scenarios to capture *a priori* non-predictable outcomes of several participatory decision-making processes. Finally, the main precautions that we think need to be taken in order to exploit integrated modelling as a component of decision-making processes for water management are briefly discussed in Section 6, at the risk of 'opening Pandora's box' of persistent controversies. Conclusions are drawn in Section 7.

2. Low-water multi-level governance in France

Several syntheses presenting the legal and administrative organization of water policy in France have been produced recently (Council of State, 2010; Gazzaniga et al., 2011) as well as evaluation reports of various aspects of water management (financing of water policy: Commissioner-General for Sustainable Development, 2011; instruments for the sustainable management of water: Court of Auditors, 2010; public services of water management and sanitation: Barucq et al., 2010, etc.). Table 1 provides an overview of the main legal instruments involved in the quantitative management of water in France. Each governance level relies on a specific variety of actors that may include end-users, managers of infrastructures, public and private companies, State services, associations, and local authorities (county, municipality). These actors are involved in management procedures of particular events, such as scarcity or "low-water" and floods, and in other issues such as water pricing, construction or maintenance of reservoirs.

In France, since the so-called "second law on water" in 1992, water management strategies and policies are designed at prime-order river basin level through participatory procedures. In these river basins, three main institutional levels and corresponding low-water management policies exist, as explained below.

2.1. Basin or sub-basin level: structural measures for low-water management

The Adour-Garonne basin is the basin with the largest water structural deficit in France. This river basin encompasses numerous irrigated farming systems that consume up to 80% of the total anthropic water consumption during the low-water period. In France, the Master Scheme for Water Planning and Management (SDAGE[1]) of each basin, approved by the Basin Committee and enacted at the basin level in the case of the Adour Garonne by the Adour Garonne Water Agency (SDAGE AGB, 2010), defines the general rules to manage water deficit within sub-basins and the main policy measures to pursue sustainable water management (e.g. premiums for increasing water use efficiency; construction of dams, financial resources for supporting studies about hydrosystems functioning, etc.) and ensuring that 60% of water masses will reach the objective of good water status by 2015 in accordance with the European Water Framework Directive (EU WFD) (2000) and the *Loi sur l'eau et les milieux aquatiques* (Law on water and aquatic environments) (LEMA, 2006). The SDAGE is endowed with a strong legal power to impose that any program or administrative decision to be compatible with its provisions in the field of water (Environmental Code, art. L212-1), and in policy domains impacting water resources (territorial coherence schemes, local urban planning, agricultural policy, etc.). Regarding low water management it defines the general orientations for the management of water resources and water demands. More particularly, it fixes, for a given number of strategic hydrological sites (64 sites in the Adour-Garonne basin) two regulatory flow levels: the *objective low-water flow* (DOE[2]) corresponding to the minimum flow that ensures locally the good functioning of aquatic environment and should be respected 8 years out of 10, and the *crisis flow* (DCR[3]) corresponding to the level under which the supply of drinking water for basic needs and the survival of the aquatic species are in danger.

The SDAGE AGB (2010) was developed in a participatory manner by seeking the opinions of a wide variety of actors: in 2008 a public consultation of citizens was conducted to gather their opinions on the draft adopted by the Basin Committee in 2007 and previously developed since 2002 by the Adour-Garonne Planning Commission assisted by various territorial commissions, local technical secretariats, local water forums, and the Technical Secretariat

[1] SDAGE: Schéma Directeur d'Aménagement et de Gestion de l'Eau.
[2] DOE: Débit d'objectif d'étiage.
[3] DCR: Débit de crise.