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Editorial

Water governance across competing scales: Coupling land and water management

1. Introduction

Water governance is becoming an increasingly important area of study for hydrologists, as the impacts of human decisions on water flows and their various management scales are recognised. Hydrology has long tackled issues of water flow and quality across basins—from rain to soil and sub-soil, from upstream to downstream, between surface water and groundwater systems, and through interlinked watersheds—with the understanding that these stocks and flows can be modified en-route due to the actions of people, including through organised water management and governance processes. In this setting, one common aim of water governance is to develop management processes and infrastructure systems that can control hydrological variability at different levels of spatial and temporal scales. For example, water storages, distribution systems and drainage networks are developed for long-term seasonal and inter-decadal variability—in the case of large dams and irrigation systems—as well as shorter-term variability, such as flooding events, that may take place over hours (e.g. urban flash floods), days (e.g. catchment-based river flooding) or months (e.g. basin-wide flood-plain inundation events). Particularly when looking at water supply issues, water allocation rules are elaborated and negotiated in order to provide water to people when and where they most need it, rather than when and where it would naturally be available.

Such decisions on water governance systems have an impact on the capacity of people and institutions to make autonomous decisions about water and land management, both within basins and in their interlinked social-ecological systems: what we will term in this paper the governance of "social-hydrological systems". Water governance affects, and is equally affected by, decision processes in a variety of other areas such as crop selection, land use policies, energy systems and environmental management. In other words, there is a range of externalities created by decisions and actions that may lead to problems for other people at different levels or scales in the governance system. Possible conflicts between the aforementioned decision areas are typically handled at a range of administrative and institutional scales (linked to geographical regions), which often do not fit watershed or groundwater reserve boundaries. Conflicts can also occur between jurisdictions and a range of interests (public and/or private), leading some hydrology academics to suggest that analysing management of "problem-sheds" may be more relevant than management of "water-sheds" to improve water governance systems.

Trade-offs have to be made between these competing scales in governance processes in order to reach decisions that are mutually beneficial for water and land management, and the people responsible for them. Yet, within decision processes, individuals and groups play major roles in constructing which scales are considered to be important, embedding their own views, knowledge and values within these preferred representations. Some act to bridge scales (e.g. knowledge brokers, boundary organisations) while others act to design and reinforce existing boundaries and scales of governance. Facilitation and coordination across competing or interlinked scales occur through both formal and informal institutions, as well as via different types of socio-technical infrastructure which include sets of rules, thresholds, indicators, models and information systems.

In this paper, we propose that many water governance challenges require multi-level, cross-scale governance processes and conflict resolution. To make this argument, we draw on the evidence of a range of papers included in this special issue, that have considered questions such as:

- How are conflicts across competing scales managed?
- What mechanisms are involved in bridging scales?
- To what extent are currently privileged scales and/or governance structures appropriate for effectively managing water? And what might be more appropriate, for example, to cope with changing regional climate and demand patterns?

Before discussing these issues and the insights from the papers, we consider it first important to define and formalise what we mean by "scale" or "level" and "cross-scale" or "multi-level" and describe a number of scales relevant to the study of water governance. We then propose a typology of externalities that can be produced at one level on a scale and the potential multi-level or cross-scale interactions that can result. We then use this typology to describe how water governance situations can be altered by specific actions and discuss the above questions, including governance mechanisms and institutions that can be used for better managing land and water conflicts across competing scales. We conclude with perspectives for future water governance practice and research.

2. Definitions and scale descriptions

2.1. Scales and levels of organisation

Scale is a commonly used word in many disciplines, including hydrology, as well as in daily language. It is therefore subject to frequent use without exact definition, which leads to it being used with different meanings and makes scholarship on scale issues challenging. In the water sector, there is a constant confusion

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between scale and levels of organisation. We should be rigorous on these definitions, although we note that multiple definitions that do not match those below are possible (Sayre, 2005). Firstly, levels can be considered as an extension of scale as a graduated range. Values constituting a whole range defining a scale can be defined within a continuous set, or a non-continuous one. The whole range is then a set of classes, which are also named "levels" or "levels of organisation". In the field of governance, both organisation levels and scales have been used increasingly interchangeably, leading to some confusion. In this paper, we will use the term "scale" when dealing with a graduated range of extent, and levels of organisation when dealing with non-continuous classes. For more in-depth discussion on these terms and more, see Gibson et al. (2000).

However, it is also important to acknowledge a second definition of scale from the Oxford Dictionary as "The relative size or extent of something" as this will be important when we discuss some of the authors' papers, especially when issues of the subjective construction of scale, or "re-scaling", processes come up.

Taking the first measurement definition, we consider that for each scale (e.g. temporal, spatial) a number of "levels" can be defined. For example, a temporal scale may include the levels of hours, days, weeks, years, centuries, etc. (i.e. different lengths of time) or a spatial scale may include the levels of ecosystem patch, catchment, river-basin or eco-region, and biome (i.e. different area sizes of geographical space). Expanding on the scale and level descriptions provided in Cash et al. (2006), in Fig. 1 we provide a number of scales that are relevant to questions of water governance with example levels. Each one of these different scales and its relevance to water governance challenges is then briefly described with reference to the literature. We note that each scale category is independent of others but may commonly be combined with others. For example, an administrative scale and spatial scale are commonly found together, as an administration at any level also typically has jurisdiction over a set spatial area or level. The list of scales is not comprehensive, as other scales could also be constructed for other purposes.

Following these individual scale descriptions, we also reflect on the issues of multi-level and cross-scale interactions and the processes of scale construction and rescaling.

2.2. Dimensions of grading

Processes related to hydrology and water governance can be described according to the entities they use and/or modify. The state of these entities is described according to various dimensions, along which they are situated. We list these various possible dimensions below.

2.2.1. Spatial scale

Space is a one of the most common dimensions, along with time (discussed next), that is most commonly considered in hydrological studies and water governance more generally (e.g. Klemes, 1983; Bergström and Graham, 1998; Sivapalan et al., 2004; Merz et al., 2009; Syme et al., 2012). Understanding the spatial scale, and how processes at different levels on it interact, has also been a major focus of other related disciplines such as ecology (e.g. Levin, 1992; Peterson and Parker, 1998), sustainability studies (e.g. Dovers, 2010); geography (e.g. Harvey, 1969; Meentemeyer, 1989; Turner et al., 1989), sociology (e.g. Tilly, 1984; Coleman, 1990) and environmental politics or political ecology (e.g. Swyngedouw, 1997; Brenner, 2001), and to a lesser extent in economics (e.g. Veldkamp et al., 2011). For water governance and hydrology, the spatial scale can be divided into a range of different series of levels based on typography or other definitions of areas (e.g. watersheds/ecosystems; administrative areas (see also Section 2.3); areas of flow-dynamics—from the micro molecular level to the macro flood-plain flow level). There are also strong debates in and across disciplines about the importance and existence of specific spatial levels, depending on epistemological and ontological positioning, about the extent to which certain levels "exist" such as the topological definition of a river basin, or are socially constructed (e.g. Swyngedouw, 2004) such as the extent of an urban area's catchment which will depend on the social definition of what is considered to be "urban" as an example (see Sayre, 2005, for further discussion).

2.2.2. Temporal scale

Time is another vital dimension considered in hydrological studies, but perhaps more implicitly considered in some of the water governance literature. The resolution or level of temporal data (e.g. minutes, hours, days, months, years) used for hydrological studies will permit different understandings of phenomena such as flash floods, rain-water tank storage levels, riverine and basin flooding, droughts and climate change patterns on rainfall and runoff. Water governance mechanisms, planning regimes and institutions may also be specifically designed to manage these phenomena and others, linking them explicitly to different levels of the temporal scale through the study of rates, durations and frequencies. There are some authors who study water-related phenomena explicitly across the temporal scale, such as Carpenter and Kitchell (1987) who investigated the influences of temporal scale variance in limnetic primary production (ecological productivity of lakes and associated food webs). Issues of temporal scale are also closely attached to spatial scale in much ecological work (as discussed in Section 2.2.1) or in studies of spatio-temporal variability in areas such as soil science and agricultural water use (e.g. Starr, 2005). Issues of temporal scales also feature prominently in some economics-based works (e.g. Dasgupta, 1997; Daly, 1992), which is of particular interest to water governance regimes which include water markets and pricing designed to support water management, use efficiency and security under specific temporalities. Two such major economics issues include: the irreversibility effect for decisions under uncertainty (Henry, 1974); and the computing of "depreciation costs", important for renewable resources management, that can make financing infrastructure development appear to be more or less economically viable. In particular, the choice of discount rate in these calculations is very sensitive to rather ad hoc choices related to the long term (Carey and Zilberman, 2002). Decisions on infrastructure or land use taken as a consequence are then non-reversible and may generate adverse effects such as agricultural land losses (Hodge, 1984). Finally, in water governance, time dimension issues and mismatches also arise linked to short-term political agendas versus longer-term water planning and sustainable development needs (see also Cumming et al., 2006).

2.2.3. Administrative or jurisdictional (legal) scale

The administrative or jurisdictional scale is concerned with administrations, such as governments or governing organisations, and the levels that they are set up at such as the local, provincial, regional, national or supra-national level. Administrations or political units at each of these levels are thus typically linked to a specific geographical level or area where they hold jurisdiction. The administrative scale is one of the most common scales evoked in the water governance literature, or the political sciences literature more broadly, with much debate over how water management administrations would be more appropriately created at the basin or catchment level, rather than being based on most existing jurisdictional boundaries that are not topologically or hydrological system-based. This is the kind of mismatch or issue of "fit" studied by authors such as Ostrom et al. (1961), Young (2002a), Cumming et al. (2006) or Moss and Newig (2010) where jurisdictional