

Interdisciplinary and participatory approaches: the key to effective groundwater management

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Abstract The challenges of a changing world, which are progressively threatening sustainable use of groundwater resources, can only be rationally and effectively addressed through close collaboration between experts and practitioners from different disciplines. Furthermore, science and management need to build on stakeholder opinions and processes in order to generate useful knowledge and positive outcomes in terms of sustainable and equitable groundwater management. This essay provides a discussion of the status of and vision for participatory and interdisciplinary approaches to groundwater evaluation and management as well as a conceptual framework and relevant research questions that will facilitate such approaches.

Keywords Groundwater management · Participatory approaches · Interdisciplinary research · Socio-economic aspects

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Scope of the essay

Groundwater is a vital source of water for human survival and livelihoods worldwide. Yet, it is confronted with huge challenges in terms of sustainable management, which will only grow as dependence on the resource and degradation impacts increase with global changes. There is a growing consensus that the challenges of the changing world—not only those related to global warming, but also land and water-use changes arising from social, political and demographic pressures—can only be rationally and effectively addressed through collaboration between experts and practitioners from different disciplines (Holm et al. 2013; Nature 2015). Furthermore, there is growing agreement that science needs to build on stakeholder opinions and processes in order to generate useful knowledge that may lead to positive outcomes in terms of sustainable and equitable groundwater management (Borowski and Hare 2007; Fritsch 2016; Pahl-Wostl et al. 2007). Effective social organization is a prerequisite for the promotion of sound governance of groundwater resources (Garduño et al. 2010; Lopez-Gunn and Cortina 2006; Mukherji and Shah 2005; van Steenberg 2006). This is because sustainable groundwater management requires both a sense of resource ownership and accountability, and close cooperation between diverse private stakeholders and the public administration. The concept of public participation in water resources management is included in key policy documents and regulatory initiatives such as the European Water Framework Directive (Quevauviller et al. 2005) and the US Clean Water Act (Carr et al. 2012; Mostert 2006). ‘Social participation’ is also an essential pillar of Integrated Water Resources Management (Foster and Ait-Kadi 2012). As a key challenge in the twenty-first century, integrated groundwater management efforts at various scales will significantly benefit from informed multidisciplinary approaches and local stakeholder involvement (Maheshwari et al.

2014; Villholth 2006). With this in mind, the authors convened a special session on Transdisciplinary and Participatory Approaches in Groundwater Research and Management at the International Association of Hydrogeologists (IAH) 43rd Congress in Montpellier, France (September 2016).

Framing groundwater assessment and management processes

Groundwater management and assessment of the resource can take various forms depending on the context, in terms of drivers, stakeholders involved, prevailing environmental and political boundary conditions, aquifer systems in question, issues at hand, and previous experience. The type of management can logically be identified by who is initiating and supporting the process, and the level and scale of engagement. This could be the government, local stakeholders and groundwater users themselves, or some external organization, like a non-governmental organization (NGO), bilateral donors or research organizations (Kool and van Steenberg 2017). While these types of approaches may not be exclusive, and ideally integration of them could enhance the overall outcome, this distinction forms a framework for description and analysis, and has implications for how such participatory processes may play out as indicated in the following.

Social science and participatory processes in groundwater management

It is necessary to explore how social science can be integrated into active groundwater management along with other key disciplines, like hydrogeology, economics and institutional law. With a view to attain broader water and environmental management goals, the interaction of hydrogeologic and social science will be critical in the discussion of: future resource scenarios, the identification of management targets, the evaluation of management interventions, the implementation of specific management measures, the monitoring of groundwater system response and the periodic review of progress and adaptation of agreed action plans. Unfortunately, there are indications that in particular the scientific groundwater community has not yet responded sufficiently to the challenge of integrating social science into the assessment and management of groundwater resources (Barthel and Seidl 2017; Seidl and Barthel 2017).

Addressing the challenges of groundwater management through hydrogeological as well as social characterization need to include: (1) the classification and understanding of groundwater use, users and potential polluters, (2) the mapping of stakeholder influences and interests, (3) the assessment of pre-conditions and previous experiences with

management of natural resources, and in particular groundwater resources and associated infrastructure (e.g. for domestic water supply or irrigation systems), and (4) the evolution of practical methods of social engagement, including systematic tools and metrics for socio-economic surveys.

This characterization should lead in turn to the identification of hydrogeologic and socioeconomic typologies, as well as feasible arrangements and necessary external support for participation, which are well suited to match the requirements of different contexts (Shah 2012). This should form the foundation, on which management interventions are developed through a more top-down approach, but also serve to strengthen already ongoing, more spontaneous, local participatory processes.

It will be important to differentiate clearly between two essentially distinct situations:

- Groundwater systems that are already subject to significant physical depletion and/or quality degradation, where there is an urgent need to support stakeholders around the agreement and implementation of a ‘sustainability intervention plan’, which will involve significant modification to existing groundwater withdrawals and land use in the longer term common interests of the entire community
- Groundwater systems that are only subject to light anthropogenic stress, where the need will be to find social mechanisms to define and adopt ‘managed development plans’

The latter situation should in general be socially easier to tackle than the former in the sense that yet no vested interests have become established. On the other hand, dealing with a crisis may, as in the first situation, be a strong trigger for creating incentives for collaboration around shared issues.

In both cases, it should be accepted that supporting a constructive social dialogue around groundwater management will gain from experienced, yet sensitive and adaptive, facilitation skills, either from external sources or from local champions. A clear focus on a specific key objective (like preventing the pollution of a drinking-water supply, halting a falling water table, protecting an ecosystem and its services, or developing a new groundwater-dependent economic activity) will help to obtain the required level of social commitment. Throughout the social dialogue and support to action on groundwater management, it is important to attract the attention of the holders of political power at various levels, and incorporate and align wider political key decision processes with local initiatives.

Enabling institutional framework for participatory groundwater management

Supporting the creation of recognized coherent social institutions, whether formal or informal, is a cornerstone, which facilitates effective decision-making and constructive

conflict-resolution. Creation of the type of stakeholder platform needed for participatory groundwater management will require:

- Sustained funding from public sources, groundwater abstraction charges or external sources
- Functioning, or at least supportive, legal authority within the provincial and national institutional framework for water resources management
- Securing and sustaining political interest and support
- Seeking active engagement and representation of all relevant stakeholders, including representatives of ‘vulnerable groups’ and of ‘environmental interests’ in decision making, and not isolating local stakeholders from higher-level governance
- Institutionalized, structured and transparent processes to facilitate evidence development, dialogue and decision making on key issues and potential conflicts
- Continuously building stakeholder knowledge and capacity for proactive participation in groundwater management, so as to create public ownership of the shared resource and compliance with agreed rules and regulations

Pilot experiences in the promotion of institutions for sustainable groundwater management on a quite widespread geographical basis confirm that some appropriate form of ‘stakeholder participation’ is an essential prerequisite for successful management interventions, but that management by stakeholder initiative alone is only occasionally sustainable under a combination of exceptional conditions. For example, where a small clearly defined aquifer system is being exploited by a socially homogenous group of users, and supported by local entrepreneurs or champions, it may be feasible (Maheshwari et al. 2014), but even then it will need to be nurtured by technical and logistic support from higher levels. In more extensive aquifer systems with major storage reserves experiencing competitive stress from large-scale withdrawals for urban utility and/or industrial water-supply and for irrigated agriculture, there is a greater need for a government agency to take the initiative on regulating groundwater use and potentially contaminating discharges, after reaching agreement on the social need for such an action plan from the bulk of stakeholders in the balance of community interests.

Lessons learned and recommendations for the scientific community

This essay does not necessarily represent all the results and opinions presented in the Montpellier Congress session. However, some important observations on the state-of-art of participatory and inter-disciplinary approaches in groundwater management could be made:

- The concept of ‘participation’ has a wide range of facets, and scientific contributions range from case studies reporting on an actual participatory process to more generic considerations of communication and knowledge transfer, or suggestions for a complete framework for participatory approaches
- The uniqueness of the experiences presented was striking—no two case studies used the same strategy, with major differences depending on environmental problems addressed, scale of issue (from village to national level), and level of capacity and experience with proactive management of groundwater.

It is concluded that social participation in groundwater management remains a challenge, and documented coordinated efforts are required for guidance (Kool and van Steenberg 2017). Participatory groundwater management needs to be merged as part of a coordinated bottom-up and top-down approach. It is important to understand the drivers and stakeholders for these types of processes, and to evaluate how they actually perform. Local management sometimes develops in response to poor formal management arrangements, as a coping mechanism and outside recognized institutional structures (van Steenberg and Shah 2003). It is important to reconcile such processes and make them mutually re-enforcing, rather than antagonistic.

Significant boundary conditions and challenges to sustainable groundwater management such as links to land tenure, energy policies, and lack of delegated authority, finances and capacity to the local level, all impede or influence the scope for participatory groundwater management. Also, when facilitated by external parties, careful consideration needs to be given to long-term sustainability of participatory processes (Verma et al. 2012). It is also important to distinguish between different stages and contexts of development.

The Montpellier discussions revealed that there is no one model for inter-disciplinary and participatory research that fits all challenges to sustainable and equitable groundwater management, and despite an ever-growing number of pilots (successful or otherwise), it is unlikely to be able to distil or prescribe a standard ‘best practice’ recipe. The role of groundwater scientists ranges from pure observation to genuine partaking. Concomitantly, the existing group of scientists analysing the findings is relatively small and somewhat disconnected (Barthel et al. 2016). Despite a growing number of useful guidelines on participatory integrated modelling (e.g. Seidl 2015; Voinov and Bousquet 2010, Voinov and Gaddis 2008), there is a tendency to develop increasingly specialized tools, which may be difficult to take up among stakeholders.

The scientific groundwater community should become involved in exploring participation in a more systematic manner, to support those concerned with questions of practical management as well as policy making with robust guidelines on successful social participation, supporting coherent and sustainable groundwater management.

The following research questions need to be evaluated systematically and in well-defined contexts:

- Who should push for (stronger) participation and how does this affect the outcome, sustainability and integrated benefits of the process?
- Which types of external involvement (information, facilitation, financing, etc.) are most successful in which context?
- Who should assume which role in the process; what are the incentives to assume various roles, and how can roles be adjusted to meet the goals of the process?
- What is the most feasible way to communicate and integrate uncertainties within highly complex systems and anticipated long-term impacts of management actions into decision-making?
- Which approaches have been successful in given hydrogeological and societal contexts, and what aspects are universal and can be transferred and up-scaled?

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