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Policy Over Practice: A Review of Groundwater Governance Research in Sub-Saharan Africa

CRAFTING COMBINATIONS TO GOVERN GROUNDWATER (GUEST EDITORS: R. MEINZEN-DICK & B. BRUNS)

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ABSTRACT

Groundwater is increasingly seen as crucial to both agricultural and domestic water supply in sub-Saharan Africa. Citing climate change and growing populations, there is especially a notable shift towards promoting groundwater for irrigation to ensure food security. Increased use of the resource will undoubtedly be accompanied with new questions of governance, with groundwater overexploitation in other parts of the world functioning as a strong cautionary tale. This article provides an overview of the current groundwater governance literature on sub-Saharan Africa. Using a critical water governance lens we analyse how groundwater governance is framed, what terms, categories, and measurements are used to describe and assess groundwater governance, and whose perspectives are considered. We also assess whether groundwater governance research has taken place across sub-Saharan African countries in a balanced way. We find that groundwater governance research in sub-Saharan Africa, even more so than elsewhere, ignores the voices and perspectives of those physically encountering the resource. Instead, it is dominated by the views of formal, technical groundwater experts focusing on the need for more hydrogeological data and formal policies. While the existing contributions to the literature are valuable, the current bias in perspectives calls for others to join the field of groundwater governance and to supplement current conceptualisations and approaches with those of users and others dealing with groundwater management on a daily basis. We argue that groundwater users' practical governance experiences, locally adapted solutions and knowledges, can add important complementary perspectives and insights towards crafting effective, sustainable and equitable groundwater governance processes across the continent.

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INTRODUCTION

Surface water resources have long been given preference in sub-Saharan Africa (SSA) by users, policy makers and academics. Whether due to practical constraints hampering groundwater development or because of conservation narratives (Cobbing & Hiller, 2019),[1] groundwater development, especially for irrigation, is lagging behind in SSA compared to other parts of the world (Siebert et al., 2010). However, in the face of climate variability, growing populations and dwindling surface water resources, groundwater has increasingly been heralded as the potential game changer for the African continent (Amjath-Babu, Krupnik, Kaechele, Aravindakshan, & Sietz, 2016; Cobbing, 2020; Cobbing & Hiller, 2019; Shah, 2005). Many studies have argued the plentiful nature of groundwater in SSA and explored its potential to provide water for domestic and productive uses (Altchenko & Villholth, 2014; Amjath-Babu et al., 2016; Cobbing & Hiller, 2019; Gowing et al., 2016; MacDonald, Bonsor, Dochartaigh, & Taylor, 2012; Nakawuka, Langan, Schmitter, & Barron, 2018). Groundwater has been identified as the driver of a "revolution" (Cobbing & Hiller, 2019) and as capable of facilitating an agricultural "transformation" (Amjath-Babu et al., 2016).

At the same time, the negative results of groundwater overexploitation due to agricultural intensification, as well as the often failed attempts at groundwater governance in other parts of the world, have been well-documented (Closas & Villholth, 2020; Molle & Closas, 2020). Zwarteveen et al (2021), analysing recent reviews on groundwater governance globally, came to the conclusion that previous studies have been "resource-oriented and intervention-oriented and assume that governing groundwater is primarily a public concern" (p.90). They call for a shift in research focus "from individuals and pumps to communities and aquifers". However, the reviews considered by Zwarteveen et al (Closas & Villholth, 2020; Molle & Closas, 2017, 2020; Molle, López-gunn, & Steenbergen, 2018; Villholth, Lopez-Gunn, Conti, Garrido, & van der Gun, 2018) primarily focus on areas where intensive groundwater use has already resulted in negative consequences (United States, India and the Middle East and North Africa). Sub-Saharan Africa is largely absent, and indeed, a quick search shows no review papers on groundwater governance with a geographical focus on sub-Saharan Africa. In general, the limited literature on groundwater governance in SSA is in sharp contrast to the extensive body of literature on general water governance.[2] This raises the question of what we know about groundwater governance in SSA, where overexploitation is not yet a common occurrence, and how research can contribute to groundwater governance on the continent.

In this paper, we provide an overview of groundwater governance research in sub-Saharan Africa. Inspired by Zwarteveen et al (2017), we focus on how groundwater governance is conceptualised by the different authors, what indicators and terms are used to study groundwater governance, and whose voices are being represented. We conclude that first of all, groundwater governance has received only limited attention. Secondly, as is the case for the rest of the world, groundwater governance research in sub-Saharan Africa has focused on governance aspects that deal with formal institutions and technical data, more specifically paper policies and laws and hydrogeological analyses, often at the national level, and almost solely represents the voices of policymakers, hydrogeologists, and other formal experts. While Wijnen et al (2012) acknowledge that the default option in most places in SSA is already for local communities to manage and control groundwater resources, there are very few studies on water users' groundwater governance practices, experiences, or knowledges. Based on a few previous studies, and our own experiences from a qualitative research project in Tanzania, we show what can be gained from expanding the current narrow focus in groundwater governance research. Ultimately, we join the call to expand the current research agenda to include studies in which water users' knowledges, experiences, and practices are central in order to assess how these can contribute to, or hinder, sustainable and equitable groundwater use.

REVIEW APPROACH

The analysis in this paper is based on a literature search in various research databases. We have primarily relied on Scopus, while using EBSCO Discovery Service and Google Scholar as complementary sources. We used the search terms "Africa AND groundwater AND governance" and "groundwater AND governance AND *SSA country*, to make sure papers concerning individual SSA countries were not overlooked. In our primary Scopus search we limited the search to papers which had our search terms in the title, abstract or keywords, while the supplementary search we did in Google Scholar also included matches in the main text. From the results, those articles that were clearly dealing with groundwater governance in sub-Saharan Africa in some form were selected. We have for instance excluded papers with a different geographical focus or those that mention governance in the abstract, but did not actually investigate or discuss governance issues. Articles referring to North Africa were excluded because the aquifer types and level and type of exploitation are markedly different between sub-Saharan Africa and North Africa (Xu, Seward,

Gaye, Lin, & Olago, 2019). Finally, we used the search term "groundwater management" instead of governance to see whether this would yield more ethnographic work or case studies on community groundwater management that would challenge the emerging picture of technocratic studies portraying the perspectives of a specific type of experts. This search yielded around ten times the number of papers than our first search using "governance", but added no additional papers, confirming the relevance and effectiveness of our original search terms. We limited ourselves to peer-reviewed articles, excluding grey literature. This resulted in a total of 49 articles, published over a 15 year period between 2007 and 2022. It should be noted that we do not claim that this list is exhaustive, as the keywords will exclude particular papers that use a different terminology, but yet might be relevant. It also excludes papers that deal with groundwater governance as part of general water governance, without specifying the role of groundwater in the title or abstract. However, we are confident that the reviewed articles form a good reflection of the current state of the literature on groundwater governance in sub-Saharan Africa and that our subsequent analysis and conclusions are valid. To analyse the selected articles, we were inspired by the opinion piece of Zwarteveen et al (2017), who advocate for using water governance as a critical concept to analyse the distribution of water, voice and authority, as well as expertise. They, like us, see this distribution as contested, and water therefore as both a socio-natural as a political phenomenon. Studying who talks about groundwater governance, with what objective and using what terms shows us whose voices, practices and knowledges are being heard, and whose are excluded. Adapting the questions raised by Zwarteveen et al, we assessed each article using the following questions: 1. How do the authors use the term groundwater governance and for what analytical goal? 2. What terms, categories, and measurements are used to describe and assess groundwater governance? 3. Whose perspective is considered when discussing groundwater governance? To this, an overview of geographical focus and level of analysis was added as a fourth point to assess whether groundwater governance research has taken place across sub-Saharan African countries in a balanced way. In the following sections, we present the detailed findings of our review (see also Annex A for a summary table).

GROUNDWATER GOVERNANCE FRAMING AND INTERPRETATIONS

Analysing the existing body of literature on groundwater governance in sub-Saharan Africa, there are four relatively distinct interpretations of what groundwater governance entails.

GOVERNANCE AS TECHNOLOGICAL INTERVENTIONS

One interpretation reflected in the literature is groundwater governance as a purely technical endeavour. Groundwater governance is reduced to technological interventions, without considering the political nature or practices of groundwater use and development. This interpretation can be found for instance in Tukur et al (2018), who state they are doing a review of groundwater conditions and management in North-western Nigeria. However, no management practices are discussed, other than recommendations for various technological measures to be taken to increase water availability (recharge, water harvesting, re-use, etc). Olivier and Xu (2019) write that "water governance refers not only to the technological solutions of water provision, as important as they are, but also to how water resources are managed, in terms of optimising the use of existing supplies as well as balancing the social, ecological and economic impacts of new sources" (p.823). This optimising and balancing however, is considered a purely technological challenge of infrastructure, water re-use and desalination.

GOVERNANCE AS FORMAL POLICY AND REGULATIONS

The second, and the most dominant, interpretation is groundwater governance as formal management, institutions and policy. In these studies, groundwater governance is interpreted and analysed based on existing paper policies, without looking at the messy realities of groundwater use in practice. Again, this depoliticises groundwater governance and turns it into a domain dominated by the state and technical experts, largely excluding groundwater users from groundwater governance. Prime examples of this interpretation can be found in Benito et al (2010) who advocate for geohydrology to be the basis of government-designed governance structures but ignore actual groundwater management and use practices in their article on alluvial aquifers in Southern Africa. Similarly, Pietersen et al (2012) analyse South African groundwater policy and laws and the government's capacity for their implementation in their status assessment of South African groundwater governance. Their conclusion points at a lack of knowledge, capable staff, financial resources and coordination but does not include an analysis of how this lack of implementation interacts with groundwater realities experienced by users. More recently, Olago (2019) did a similar analysis for five Kenyan towns, in which the definition of governance

excluded all non-governmental actors: "Governance refers to the oversight and decision-making that provide strategic direction relating to policies, plans and strategies that provide guidelines for management" (p.1041–1042). This exclusion of groundwater users as anything other than the target of government policies ignores the agency of these users in shaping groundwater use and management, and can also be found in a multitude of other publications (e.g. Braune & Xu, 2008; Comte et al., 2016; Foster, Tuinhof, & van Steenbergen, 2012; Gaye & Tindimugaya, 2019; Knüppe, 2011; Mengistu, Demlie, & Abiye, 2019; Ngounou Ngatcha, Mudry, & Leduc, 2008; Pienaar et al., 2021; Seward, 2010; Seward & Du Toit Van Dyk, 2017; Viljoen, 2020).

GOVERNANCE AS MANAGEMENT OF WATER SUPPLY

A third interpretation is one in which groundwater governance is actually conflated with the management of groundwater technology such as boreholes and standpipes. Essentially, this relates to water supply, primarily in rural areas, not to the actual governance of the resource or the aquifer. The crucial question is not how groundwater resources can be shared, known, used, or protected, but how to ensure the financial and technical sustainability of rural water supply services. Examples of such an interpretation can be found in Carter and Bevan (2008), who argue that lower drilling costs and the sustainability of water points are crucial for extending access to groundwater for domestic, agricultural and small-scale industrial use; Van den Broek and Brown (2015), who challenge whether community-based management is the appropriate form of management for rural water points; and Gudaga et al (2018), who assess the effectiveness of institutions around groundwater-based rural water supply in three villages in Tanzania.

GOVERNANCE AS GROUNDWATER PRACTICES

The fourth understanding of groundwater governance is one that sees groundwater governance as a process which takes places at both the local level of water users and at the higher levels of formal government. This interpretation is the least common, though it is becoming more present in recent publications. In older articles (pre-2020), this understanding of groundwater governance as groundwater practice is often expressed in a minimal way, by at least acknowledging local water management structures, such as done by Day (2009) who mentions sheikhs as water managers in Sudan. Similarly, Adams et al (2015) do acknowledge that there are three levels of groundwater governance in South Africa: the level of policy, the national/strategic level (national institutions), and local level (actual groundwater managers) but their subsequent analysis is based primarily on literature describing policies and programmes, without involving any empirical material concerning the local level. A more explicit earlier expression of this interpretation is the paper by Kwoyiga and Stefan (2018) who present a detailed case study of indigenous knowledge and practices of well siting and groundwater development in Northern Ghana, including taboos, norms and beliefs that influence where groundwater can and cannot be used. In later articles, since 2020, the interpretation of groundwater governance as a process involving both local practices and formal policy is actually dominant. These articles include a detailed discussion on the meaning of (good) groundwater governance as an inclusive process that takes into account the views of scientists, policy makers, groundwater users (Seward & Xu, 2019), a call to look beyond state-led groundwater governance to a more diverse range of opportunities for supporting local collective action (Bruns, 2021), as well as a case illustrating how citizen science can contribute to co-learning and co-creation of knowledge on groundwater systems (Goldin, Mokomela, Kanyerere, & Villholth, 2021). In addition, Bellwood-Howard et al (2022) showcase stakeholders' perceptions on groundwater governance, while Ciampi et al (2022), focusing on groundwater use for sustainable intensification in Burkina Faso, see local groundwater use practices as well as information sharing and conflict resolution as part of groundwater governance.

TERMS, CATEGORIES, AND MEASUREMENTS

More even than surface water, groundwater governance is the field of specific technical experts, which is also reflected in the terms and categories that are used to talk about groundwater governance. The prevalent terms for discussing groundwater governance reflect the dominant understanding of groundwater governance discussed in the previous section. Broadly speaking, it is possible to distinguish between three sets of terms, categories and measurements that are used frequently in the groundwater governance literature. Below we discuss the sets of terms concerning hydrological data and formal policies together, as they are often combined, before moving on to a less common set of terms reflecting practices, knowledges and equity and sustainability outcomes.

HYDROLOGICAL DATA AND FORMAL POLICIES

The first set of terms, categories and measurement concerns different types of hydrogeological data (aquifer characteristics, abstractions, recharge), as well as the level of completeness of this data. Here, the availability of

data is a measurement, and precondition, of groundwater governance success in itself. In one of the first publications on groundwater in Africa for instance, several authors call for more hydrological data on groundwater resources to enable the expansion of groundwater use and the sustainable management of groundwater (Adelana & MacDonald, 2008). The much-repeated slogan among groundwater researchers that "you cannot manage what you do not measure"[3] is a perfect example of the emphasis on hydrogeological data as a prerequisite for groundwater governance.

The second set of terms concerns formal policies, laws and regulations. Again, not only their content, but also their mere existence is used to evaluate and measure the success or adequacy of groundwater governance. A clear example is the article by Nijsten et al (2018) on transboundary aquifers in Africa. In their analysis of the progress of transboundary aquifer governance they essentially list the different agreements and frameworks that exist for various transboundary aquifers on the continent. Another example is Viljoen (2020), who discusses the legal concept of public trusteeship as an appropriate approach to groundwater governance in South Africa.

However, most publications actually mix terms from the first and second set, in which a full hydrological understanding of aquifers is deemed necessary for properly designing and implementing the right government policies for governing groundwater. Often, these are inspired by Integrated Water Resources Management (IWRM) principles, such as the article by Braune and Xu (2008). Based on a desk study of available policy and scientific documents, the authors conclude that "the SADC has made considerable progress in bringing important groundwater resources into an IWRM framework. However, this is not yet reflected in the groundwater resource management situation in individual countries, which is still rated 'below expectation'" (p.703). The considerable progress mentioned is assessed, among others, based on whether groundwater is included in regional and national policies and programmes, level of groundwater investment, groundwater's integration in water user associations' and river basin organisations' activities, and the level of groundwater monitoring and aquifer assessments. Without explicitly referring to IWRM, Pietersen et al (2012) evaluate groundwater governance in South Africa using the extent to which the national policy is implemented, the availability of hydrogeological data, the presence of groundwater maps, the capacity for quality and quantity monitoring, and the ability to control abstraction and pollution. Similar categories and terms can be found in a variety of other studies (Benito et al., 2010; Foster et al., 2012; Gaye & Tindimugaya, 2019; Knüppe, 2011; Mengistu et al., 2019; Olago, 2019; Varady, Zuniga-teran, Gerlak, & Megdal, 2016). In a recent review paper on the implementation of groundwater protection measures in South Africa Pienaar et al (2021) also discuss institutional and governance arrangements, and what is lacking. They, for example, point out that more detailed and better hydrological understanding of aquifers would require new investment into aquifer information and groundwater monitoring and that a country-wide implementation of the National Water Act will depend on a strong regulatory framework and the existence of effective regional and local institutions. However, with reference to previous research on groundwater governance in South Africa and to the review by Molle and Closas (2017), they also acknowledge the importance of "co-management of groundwater resources through appropriate forms of shared decision-making by a diversity of actors at both national and local levels", and the need to approach groundwater governance as "an ongoing and organic process". Hence, while the bulk of this paper deals with issues of formal governance arrangements and hydrological data, it also exemplifies an emerging awareness of the importance of not reducing groundwater governance to the necessity of more accurate data and properly designed and implemented formal policy and regulations.

GROUNDWATER PRACTICES, KNOWLEDGES AND OUTCOMES

The third set of terms concerns actual management practices, groundwater knowledges and outcomes in terms of access, equity, and sustainability. It is this third set that is underrepresented compared to the other two. They are generally used in the very few case studies that exist on groundwater use, development and governance in sub-Saharan Africa. Colvin and Saayman (2007) for instance assess groundwater governance in Cape Town in terms of sustainability, efficiency and equity. The unique element in their study is that they focus on groundwater users (urban residents watering their gardens) and their understanding of groundwater as a resource and the impact of increased groundwater use. One of their results was that "the traditional view of groundwater as private water is in part underpinned by a static (stagnant) conceptualisation of the aquifer as a system in which very little flow occurs" (p.136). Here, they link people's conceptualization of groundwater to behaviour in assessing the potential impact of groundwater governance measures. Day (2009) provides a different set of measurements and categories for groundwater monitoring based on practices by communities in Sudan. Rather than talking of recharge, abstraction and groundwater levels based on hydrological models and measurements, Day provides examples of community members assessing the length of a rope tied to

a bucket when fetching water, marks on well walls during dry and wet seasons, the ease of using a hand pump, and the number of weeks rainfall had occurred. These observations are linked to various management practices such as the deepening of wells and the prioritization of certain water uses. At a larger geographical scale, Cobbing and Rose-Innes (2018), Cobbing and De Wit (2018), Komakech and De Bont (2018), and Hawkins et al (2019) all assess groundwater governance in practice, in which equitable access and sustainability are the main terms used for assessment.

VOICES AND PERSPECTIVES

Considering the dominant understanding/framing of groundwater as a technical issue and the prevalent hydrogeological and institutional terms in which groundwater is discussed, it is unsurprising that the considered perspectives on groundwater governance have been almost exclusively limited to those of scientists, policymakers, and national government employees. This logically influences what recommendations are made in dealing with groundwater. Knüppe (2011) for instance aims to contribute to "the small existing volume of academic literature on groundwater governance structures, alternative management approaches and resource protection in South Africa" (p.68), and does this primarily by evaluating the existing policies, laws and government organisations that are involved in groundwater management in South Africa. In addition, she interviewed experts from different national government departments, research institutes, and conservation organisations. The key findings and resulting recommendations subsequently centre on calls for more funding, more research, more hydrological data, and more institutional development to enable state control. A similar point is made in the review paper by Pienaar et al (2021) on groundwater protection measures in South Africa where they conclude that a key problem is a lack of capacity in municipalities as well as a systemic lack of support and regulation.

The exceptions that do include the perspectives of local level government employees or groundwater users have been mentioned before as those studies that frame groundwater governance as a political issue and discuss groundwater governance in terms of equity and sustainability and acknowledge various knowledges (e.g. Bellwood-Howard et al., 2022; Bruns, 2021; Ciampi et al., 2022; Cobbing & De Wit, 2018; Cobbing & Rose-Innes, 2018; Day, 2009; Goldin et al., 2021; Hawkins et al., 2019; Komakech & de Bont, 2018; Nigussie, Barron, Haile, Lefore, & Gowing, 2018). Nigussie et al (2018) and Hawkins et al (2019) are so far the only studies that have tried to incorporate a gender focus in their studies of groundwater governance, and are therefore noteworthy. Although the first paper primarily focuses on gender and participation in citizen science related to groundwater monitoring and the second is more about water supply management, they do recognise and highlight women's voices and perspectives in a way other publications do not, even if some of the more recently published papers do mention gender perspectives and note the importance of including gender as an analytical lens (Bellwood-Howard et al., 2022; Ciampi et al., 2022). More specifically, both Nigussie et al (2018) and Hawkins et al (2019) address questions around the different ways in which men and women use different water sources, including private/communal shallow wells, and how they participate in formal water management institutions.

Finally, we note a clear tendency that papers published more recently are more likely to articulate the importance of pluralising perspectives and adding voices to groundwater governance research and policy making processes. For example, in his discussion about polycentric governance, Bruns (2021) argues that instead of a state-centric perspective where stakeholders are invited to participate in government-led policies and projects, an extended ladder of participation approach should be concerned with how governments might participate in groundwater governance where others take primary roles. On a similar note, Goldin et al (2021), discuss the potentials and complexities of citizen science and the co-generation of groundwater knowledge based on a case study of a small river catchment in the Limpopo Province, South Africa, and argue that the polycentric nature of groundwater governance "requires the agility of a bricoleur" (p.43) who adjusts and adapts to changing socio-political environments.

GEOGRAPHICAL LEVEL OF ANALYSIS

The geographical distribution of reviewed articles is strongly skewed towards South Africa. Out of the 49 reviewed articles, 20 dealt with South Africa (for instance Colvin and Saayman, 2007; Benito et al., 2010; Pietersen et al., 2012; Cobbing and De Wit, 2018), while 40% of the most prolific authors (3–5 articles on groundwater governance each) were based at South African institutions. This is possibly an expression of South Africa's relatively high level of groundwater use for domestic and agricultural water supply compared to other countries in sub-Saharan Africa – at 65% it uses the third-highest percentage of its renewable groundwater resources, only after Djibouti and Mauritania (Cobbing & Hiller, 2019). In addition, South Africa has one

of the most elaborate water laws and there is groundwater expertise at South African universities, with a special UNESCO chair in geohydrology at the University of Western Cape. This focus on South Africa does not necessarily reflect its abundance in terms of groundwater storage or recharge however. While South Africa has a relatively large groundwater storage (in SSA only Botswana, Mauritania, Mali, Niger, Congo DRC, and Chad have larger storages), its annual recharge is smaller than 18 other countries, most notably Cameroon, Congo and Congo DRC (MacDonald et al., 2012). In addition, looking at the irrigation potential using groundwater resources, Altchenko and Villholth (2014) estimate that the percentage of cropland irrigable with rechargeable groundwater is high in countries like Angola, Congo DRC, Congo, Gabon, Liberia, Madagascar, and certain parts of Ethiopia, Tanzania, and Mozambique. South Africa on the other hand has relatively little potential for irrigation using rechargeable groundwater. Even in absolute terms the potential acreage of groundwater irrigation is much smaller in South Africa than in other countries. Therefore, while institutional, legal and economic factors might skew research efforts towards South Africa, it is important for future research to include other countries with high groundwater potential and use.

There is also a bias towards studies at a larger geographical scale, either at continental, country or aquifer level, which matches the dominant framing, terms and perspectives in groundwater governance literature. The lack of studies that focus on local, place-specific contexts facilitates the kind of research that we have shown dominates this body of literature. Reversely, the studies at a larger geographical scale are likely to overlook localised action by individual water users and communities.

IMPLICATIONS OF LOOKING AT GROUNDWATER PRACTICES AND KNOWLEDGES

It is widely accepted, and illustrated by the articles on groundwater practices cited in this review paper, that a government's vision of what groundwater is, how it should be used, and how it should be governed, diverges from the existing groundwater imaginaries, knowledges and practices at community level (Zwarteveen et al., 2021). However, as elaborated above, while the government's vision is well-represented in the literature, those actors actually encountering the resource are mostly ignored. The papers that do focus on lived groundwater realities of those that are in daily contact with the resource immediately show the value of research that engages directly with how local users, administrators and communities experience and contribute to shaping groundwater governance. We expand on some of these examples below, and supplement these with two innovative approaches to expand the domain of groundwater governance research: the Transformations to Groundwater Sustainability Project and the Bir Al-Nas approach.

Where most groundwater monitoring programs rely on monitoring wells and hydrochemical analyses, Day (2009) shows how Sudanese communities instead measure water availability by the length of the rope that is needed to fetch water with a bucket. The authors of this literature review found a similar practice among communities in Tanzania, where the question about dropping water levels yielded no response, but probing into varying rope lengths helped farmers explain fluctuation in water availability in their shallow dug wells. This shows that alternative ways of looking at groundwater monitoring can yield new information, especially in areas where other hydrogeological measuring options are limited.

Existing groundwater policies are generally based on an imaginary of groundwater in terms of hydrogeology, aquifers, flow rates, and sustainable yields. In this imaginary, groundwater is conceptualized as a limited, common pool resource that should be shared by all users within a certain aquifer. This groundwater imaginary often does not match the conceptualizations of groundwater of actual users, which may explain the many failed attempts at groundwater governance across the globe. Colvin and Saayman (2007) showed the value of asking urban water users in Capetown about their understanding of ground water when they found that half of them considered groundwater to be stagnant under their properties. When asking a similar set of questions about the nature of groundwater to farmers in Tanzania, we found that most of them imagined groundwater to be an underground river, or an underground lake. Specifically, when asked what would happen to the groundwater under their farm when left untapped, many agreed it would simply sit there. Joint imaginaries of groundwater between groundwater users, groundwater developers such as well diggers, and government actors could go a long way in articulating groundwater governance programs that resonate with all stakeholders. Presenting a pilot study in Andhra Pradesh, India, Meinzen-Dick et al (2018) for instance show how collective action games around groundwater can be one way to create a shared local understanding of the relationship between for instance groundwater availability and crop choice and to promote the collective governance of groundwater.

Finally, most formal, top-down groundwater schemes start with a thorough hydrogeological study to assess groundwater availability and financial feasibility. In large

parts of sub-Saharan Africa however, this kind of information on groundwater availability and feasibility is limited. This has not stopped farmers from developing groundwater for irrigation through farmer-led irrigation development, often based on local knowledge of the resource (de Bont, Komakech, & Veldwisch, 2019). Kwoyiga and Stefan (2018) show how well diggers in northern Ghana use certain indicator species of plants to assess the best location to access groundwater. While this local knowledge primarily concerns shallow groundwater, it is nevertheless used to drive groundwater expansion in the absence of detailed, formal hydrogeological studies.

When it comes to expanding the voices and knowledges represented in groundwater governance research to capture more of the kind of valuable insights such as these described above, one inspiring approach is the socio-hydrogeological Bir Al-Nas approach, coined by Re (2015). Short for Bottom-up IntegRated Approach for sustainabLe grouNdwater mAnagement in rural areaS and meaning "the people's well" in Arabic. This approach argues for applying the concept of socio-hydrology (Sivapalan, Savenije, & Blöschl, 2012) to groundwater research. The resulting socio-hydrogeology aims "not only to study the relations between people and groundwater (...) but more generally to foster the inclusion of the social dimension in hydrogeological investigations" (p.1296). This type of research gives a prominent place to local knowledge, community-identified challenges and the proper sharing of research findings with a wider audience (Hynds et al., 2018; Re, 2015). As such, a socio-hydrogeological approach can provide a tool to formulate transdisciplinary research projects that encompass a variety of researchers and water users and contribute to a better and more holistic understanding of groundwater governance in sub-Saharan Africa.

Another example of an attempt to expand the domain of groundwater governance research is the Transformation to Groundwater Sustainability project,[4] a project in which we both have participated in as researchers. This transdisciplinary project focused on studying promising grass-roots initiatives of people organizing around groundwater, emphasising practices of knowing, accessing and sharing groundwater. The overall aim of the project was to unite researchers, activists, communities and policy makers in a shared quest to achieve more sustainable and equitable modes of groundwater governance. The resulting studies were various: Cleaver et al (2023) for instance draw attention to how groundwater is physically encountered and experienced as a lively resource by water users in Tanzania and Zimbabwe; Saidani et al (2023) analyse two long-standing community aquifer-recharge-and-use systems in Algeria and India and show how such systems require shared, practice-based knowledge of the complex interactions between surface and groundwater as well as robust and adaptive collective action to maintain and operate common infrastructure; and Verzijl et al (2023) describe dowsing/water divining and groundwater modelling in Tamil Nadu, India, as two groundwater logics that have many things in common, despite their differences, and should both be considered as having something to offer when it comes to sustainable groundwater governance. These studies illustrate the plurality of practices that surround groundwater and the importance and potential benefit of studying these.

CONCLUSION

Our detailed and systematic review of SSA groundwater governance literature shows that groundwater governance research so far has been strongly dominated by the voices, categories and framings of groundwater experts focusing on hydrogeological data and formal policies. The dominant authors in the groundwater governance research field are scholars based at engineering, hydrology, geology, and environmental sciences departments. As such, it is perhaps not surprising that they have conceptualised groundwater governance as the subject of natural science enquiries and a specific type of social engineering with formal, often blueprint-like, IWRM inspired, institutions at its core. Reflecting on the way groundwater and groundwater governance are known through the use of different categories and terms, it is clear that those relying on formal expertise of hydrology and institutions are most dominant. It is noteworthy that groundwater governance is known primarily through the analysis of documents and by the application of models, rather than by studying groundwater governance in practice. It is also remarkable that both the dominant hydrological terms and categories and the institutional ones often assume scarcity and a need to map and control, yet exist alongside statements about the unused potential of groundwater resources. All this serves the purpose to cement the role of hydrogeologists, policymakers and state agencies in controlling groundwater resources by framing groundwater as a fragile resource that can easily be overexploited, even when there are very few signs of such overexploitation at present in many parts of SSA where groundwater development is on the rise. There is a strong geographical bias towards South Africa and towards country- or aquifer-based studies. For many SSA countries, there has not been any attention paid towards groundwater governance, and there are few localized

case studies that represent the voices and knowledges of groundwater users. These lacunas provide clear topics for future research in terms of both expanding the geographical area and topics covered.

While the current scientific contributions are valuable and important, the lack of in-depth qualitative groundwater studies by social scientists is leaving us with an incomplete picture of groundwater practices and knowledges across the continent. Although there is a general and increasingly clearly articulated agreement that bottom-up involvement of stakeholders is crucial for groundwater governance, very little research has actually been done on what this local level governance looks like. Attention has focused on formal national-level institutional and legal frameworks, but local level practices and institutions (formal, informal or bricolaged[5]) largely remain unexplored. The few examples of this kind of studies, as well as our initial experiences from Tanzania, show the potential value of research that shows the plurality of groundwater knowledges and practices that exist. The current lacuna in the field of groundwater governance calls on critical social scientists and others interested in similar questions to supplement current conceptualisations and approaches with those of users and others dealing with groundwater management on a daily basis. In order to do this, scholars can draw inspiration from studies in sub-Saharan Africa as well as other geographical locations, while keeping in mind the diversity among and within groups of groundwater users in terms of identity, customs, culture, and capacity.

Ultimately, whatever approach is used, there is a need for research that encompasses more than a technocratic view and that moves beyond the rigid boundaries of the scientific community. The current limitation in perspectives, we argue, calls for scholars to represent the voices and experiences of those encountering groundwater physically on a daily basis. In addition, it calls on funding agencies and universities to encourage and facilitate social science research in this field that has so far been mostly covered by natural scientists, as well as help researchers overcome the challenges that are inherent to inter- and transdisciplinary studies. The type of research we propose will be able to shed light on the relationship between formal policy and groundwater users' lived realities, give insights into where and when these match or conflict, and thereby provide a step towards better groundwater governance for specific socio-natural configurations. Recognising the heterogeneity of groundwater users' practices and knowledges as well as their varying impact on their socio-natural environment, and without presenting community management as a cure-all or a one-way route to sustainability, we argue that more insight in groundwater users' practical governance experiences, locally adapted solutions and knowledges, adds important complementary perspectives towards crafting effective, sustainable and equitable groundwater governance processes across the African continent.

NOTES

1 For a lively discussion on this topic, also see the Water Alternatives "Water Dissensus Forum": "Groundwater shortage or crisis narratives are restricting development in Sub-Saharan Africa" – https://www.water-alternatives.org/index.php/blog/groundwater-africa.

2 Where a Scopus search for groundwater governance in SSA countries in November 2023 yields 73 results, water governance yields 1235.

3 This slogan featured prominently for instance in two recent seminars on the future of groundwater in SSA: "The role of groundwater in advancing Africa's socio-economic development" organised by AMCOW on May 20, 2021; and "Transforming Food Systems from the Ground Up: The Potential of Groundwater in Achieving Food Security and Prosperity in Africa" organized by IFPRI on July 6, 2021.

4 www.t2sgroundwater.org.

5 Institutional bricolage refers to "a process by which people consciously and unconsciously draw on existing social and cultural arrangements to shape institutions in response to changing situations" (Cleaver, 2001, p. 26).

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Annex A.** Summary table. DOI: https://doi.org/10.5334/ijc.1313.s1

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COMPETING INTERESTS

The authors have no competing interests to declare.

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