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Polycentric Groundwater Governance: Insights from the Kavango-Zambezi Transfrontier Conservation Area

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

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ABSTRACT

This paper analyses groundwater governance within a transfrontier conservation landscape. Given the current heightened interest in groundwater development, it is imperative that more thought be given to how groundwater resources can best be managed in different contexts for multiple uses and users. Transfrontier conservation areas are areas of vast biological diversity whose functioning and ecosystem integrity depends on the availability of water to sustain ecosystems and subsequently derive economic benefit. Further, climate vulnerable rural communities depend on and form an important part of this landscape. The work highlighted in this paper is based on a study conducted in parts of the Kavango-Zambezi Transfrontier Conservation Area (TFCA), the largest TFCA in the world. Climate induced challenges such as droughts and general poor land use planning have resulted in threats to long term sustainability of freshwater ecosystems and increased incidences of human-wildlife conflicts over limited water resources. Effective groundwater governance can potentially provide pathways for alleviating these challenges.

Building on the theoretical fundamentals of polycentric governance, this paper analyses the case of the KAZA TFCA in which multiple levels of governance exist. The paper discusses how to achieve coordination and accountability within a shared landscape to foster sustainable use and management of groundwater. Groundwater within a TFCA context has the potential to alleviate human-wildlife conflict over freshwater, support groundwater dependant ecosystems and sustain smallholder agriculture for the rural communities. Understanding this role of groundwater adds to the framing of freshwater governance and conservation efforts within a TFCA and the identification and development of platforms for the integrated management of groundwater. Bringing together freshwater and conservation institutions in a multi-country context towards integrated water resource management is an initial and novel attempt which forms the foundation for achieving optimal governance approaches in the commons.

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INTRODUCTION

For millions of people in rural sub-Saharan Africa, groundwater is the only source of clean, reliable water for domestic and productive uses (Pavelic et al., 2013). In the semi-arid regions of southern Africa, this reliance on groundwater is even more pronounced given rainfall variability and frequent droughts. Groundwater is also an essential lifeline for maintaining ecosystems (Cuthbert et al., 2019). Further, mounting pressure on surface water both on quality and quantity has seen attention shifting to the potential of groundwater to mitigate against water availability challenges by acting as a buffer during long dry periods (Ebrahim & Villholth, 2016). Research findings have indeed supported this potential for groundwater to withstand the impacts of climate variations to provide a reliable source of water (Marchionni et al., 2020; Vouillamoz et al., 2015). However, there have been concerns about groundwater governance approaches and their success in supporting the ever-increasing use of the resource (Molle & Closas, 2020). As such, the past decade has seen mobilisation for action towards strengthened groundwater governance systems (Petit et al., 2021).

Context in groundwater governance is especially pertinent and dictates which approaches work best (Varady et al., 2016). In transfrontier conservation areas (TFCAs), groundwater governance means interaction between different, context-specific actors and institutions.

TFCAs are conceptualized as possible peace-building mechanisms also referred to as peace parks or transboundary conservation areas (Carius, 2006; Hsiao & Le, 2021). It is believed that building cooperative arrangements around shared natural resources allows for peaceful conflict resolutions (Büscher, 2010). Such cooperative arrangements have been framed as able to withstand political unrest between their constituting nations (Carius, 2006). Indigenous communities that inhabit TFCAs are the primary custodians and beneficiaries of natural resources (SADC, 2019). Nonetheless, there are documented controversies around the establishment of TFCAs and the sociopolitical power dynamics that ensue (Büscher, 2010). These are related to unrealized benefits by local communities and the disruption of livelihoods in the transition to conservation (Mogende, 2016; Sinthumule, 2017). The dual value proposition of TFCAs linked to ecotourism and improved livelihoods (Büscher, 2010), requires a more integrated governance approach to natural resources including fresh groundwater.

TFCAs are ecologically connected landscapes supporting habitats and biodiversity. However, habitat fragmentation due to population increase, agricultural expansion and climate variability, and the lack of integration among the governance structures for groundwater – from transboundary to national and local structures, are among the risk factors that can threaten ecosystem integrity in TFCAs (Munthali et al., 2018). Groundwater plays a key part in ensuring that wildlife and other freshwater ecosystems are sustained. In the face of increasing temperatures and prolonged drought periods, it is critical to gain more insight into the role of groundwater in supporting livelihoods and connecting ecosystems. Local communities are especially pertinent to consider in the overall governance infrastructure as their livelihoods depend on common water and terrestrial ecosystems. Appendix A provides a more detailed discussion of transfrontier conservation issues related to groundwater access, human-wildlife conflicts, and biodiversity.

Therefore, the objective of this paper is to explore the challenges, dynamics, and opportunities for advancing transboundary management of groundwater resources through improved governance across scales in the context of the Kavango Zambezi (KAZA) TFCA. Using the concept of polycentric governance to explore this research objective, the paper proposes mechanisms to enhance and strengthen existing governance systems. This is important to ensure effective functioning of already existing structures and to avoid misaligned management actions that do not serve the ultimate sustainability of ecosystem functions.

CONCEPTUAL FRAMEWORK

ADVANCES IN GROUNDWATER GOVERNANCE

Groundwater governance frameworks are comparatively less advanced in most parts of the world compared to those on surface water (Ross, 2012). Megdal et al. (2015) define groundwater governance as "the overarching framework of groundwater use laws, regulations, and customs, as well as the processes of engaging the public sector, the private sector, and civil society". This definition attempts to cover the complexity and breadth of actors often encountered in groundwater governance. Pahl-wostl (2017) suggests that 'governance sets the rules under which management operates' and includes formal and informal institutions that establish rules and norms.

Across the world, licensing has been a conventional approach to regulating the use of groundwater. Nonetheless, enforcing such regulations has been a major stumbling block due to limited capacity to enforce regulations for an invisible resource (Holley et al., 2020). Molle and Closas (2020) highlight that success in groundwater governance is rare but the co-management approach which seeks to bring state actors and water users together around sustainable governance models for groundwater use

may yield more positive results. Zwarteveen et al. (2021) argue for the importance of collective action against the dependence on government-controlled regulation of groundwater use. Despite these multiple perspectives, Megdal et al. (2015) suggest that a successful groundwater governance framework should be able to (i) cope with the limited and often deficient knowledge of the groundwater resource (ii) resolve conflicts on the use of the resource (iii) link across scales, and (iv) be adaptable to change. Jakeman et al. (2016:7) see groundwater governance as a combination of "responsible collective action to ensure control, protection and socially sustainable utilisation of groundwater resources and aquifer systems". It is therefore apparent that groundwater governance can be a complex undertaking, sensitive to contextual differences and aquifer geo-physical characteristics (Albrecht et al., 2017; Varady et al., 2016).

A POLYCENTRIC APPROACH TO GROUNDWATER GOVERNANCE

A complex ecological system such as the KAZA TFCA, with high levels of co-dependencies requires a governance system or structure that responds to this complexity. It may not be operationally feasible for such a system to have one centre of decision making that encompasses the full scope of governance tasks. This observation was first made by Ostrom et al. (1961), in their quest to understand governance in metropolitan jurisdictions. They saw functions provided by multiple centres, and proposed a decentralised system of governance whose potential strength draws from the diversity of actors (public, private, local) to reach more favourable outcomes. This formed the basis of polycentricity as it is understood today in governance literature. The key features of polycentricity involve multiple levels, self- organisation or autonomy and mutual reorganisation over time to match evolving needs and demands – with a strong bottom-up focus (Jordan et al., 2015; Morrison et al., 2023). A polycentric approach to groundwater governance therefore relates to the decentralisation and distribution of decision-making powers across different scales and sectors with effective coordination mechanisms that result in better governance outcomes (Pahl-wostl, 2017).

This theoretical foundation has advanced over the years and applied in various contexts including in natural resource systems (Nagendra & Ostrom, 2012; Jordan et al., 2015). In such natural systems, research findings have shown that no one simple solution pitched at any scale is sufficient. What is required is a complementarity across scales formed by vertical coordinating approaches from national to local government through to non-governmental agencies and local communities (Nagendra & Ostrom, 2012).

Polycentricity has potential to provide the checks and balances required for dealing with complex systems where integration and coordination across scale, of actors should result in cross-learning that ensures sustainability overall (Megdal et al., 2015). Further, taking polycentricity as an analytical framework allows for imagining other ways of interaction across decision-makers with varying views and perspectives (Aligica & Tarko, 2012). Carlisle & Gruby (2019) further add that the multiple decision-making centres or units in a polycentric system often overlap and are not necessarily discrete and isolated in function, thereby supporting a feedback mechanism and mutually reinforcing actions.

Despite the promise that polycentric governance holds where multiple decision making centres operate independently but contribute towards the overall goal – there are a number of issues identified by authors such as McGinnis (2016). First, for polycentricity to be effective, there has to be a degree of autonomy where rules can be interpreted and changed by affected actors. However, this is not always the case as in top-down approaches where there may be no avenue to contest or negotiate decisions (McGinnis, 2016). Second, the success and long-term sustainability of a polycentric system rests on effective coordination pathways – which is not a straightforward undertaking in a complex socio-ecological system (Morrison et al., 2023). Lastly, polycentric systems require significant levels of interaction across the various actors and policies which may result in actor fatigue (Morrison et al., 2023). Nonetheless, the empowering features of polycentricity that enables local level governance and bottom-up coordination are worthwhile to explore in groundwater governance.

RESEARCH METHODS AND CASE STUDY AREA

This paper is based on an analysis and review of the groundwater governance landscape in the KAZA TFCA, conducted as part of a project[1] implemented over a period of two years. The project titled Sustainable Groundwater Development and Management for Humans, Wildlife, and Economic Growth in the Kavango Zambezi Transfrontier Conservation Area (KAZA-GROW) comprised several studies including an extensive transboundary diagnostic analysis to establish physical, socio-economic, institutional, and environmental baseline conditions (Villholth et al., 2022). The project was informed by a combination of literature reviews, national policy document analysis and key informant interviews with local communities in Western Province of Zambia (Sesheke, Sioma and Shangombo

districts) and in Angola (Jamba-Luiana district). In addition, stakeholders from government and private sector across the five countries were consulted at various stages of the project to gain further insights into how groundwater use is regulated at the national level. Interview questions covered three areas of groundwater governance (i) access (ii) practices and (iii) decision making. The analysis in this paper is therefore based on a synthesis of the insights from the various research activities undertaken throughout the project (Villholth et al., 2022).

THE STUDY AREA

The KAZA TFCA (Figure 1) is one of 18 TFCAs in southern Africa. It is a conservation and development initiative of the Governments of Angola, Botswana, Namibia, Zambia, and Zimbabwe signed into existence by the 2011 KAZA Treaty, extending nearly 520,000 km^2 in parts of the Okavango and Zambezi River basins, making it the largest terrestrial TFCA in the world (Bollig & Vehrs, 2021). As with other TFCAs in southern Africa, KAZA TFCA was established under the auspices of the Southern Africa Development Community (SADC) to foster regional cooperation in conservation and development of shared natural resources.

A key priority for the KAZA TFCA is to strengthen the connectivity between individual protected areas and to re-establish and/or conserve large-scale ecological processes including the integrity of the ecosystem and wildlife mobility across the region. KAZA TFCA aims to secure natural resources for the good of people, nature and economic growth. All Partner States (Angola, Botswana, Namibia, Zambia and Zimbabwe) sharing the TFCA are undergoing economic and population growth which exerts demands on the natural environment. The total population within the TFCA is close to 3 million (KAZA TFCA, 2014) with an average annual population growth rate of 2.4%. More than a third of the population is estimated to live below the poverty line (Villholth et al., 2022). Long-term trends indicate a warmer and drier climate with more variability in water availability, flood risks and longer droughts. At the same time, the KAZA TFCA is experiencing threats from climate change, land-use changes, infrastructure development and population growth which exert pressure on its natural resources with repercussions on ecosystems, biodiversity, water security, and human health and livelihoods (Villholth et al., 2022).

Rural communities, mostly reliant on water from rivers and shallow groundwater resources for their domestic and

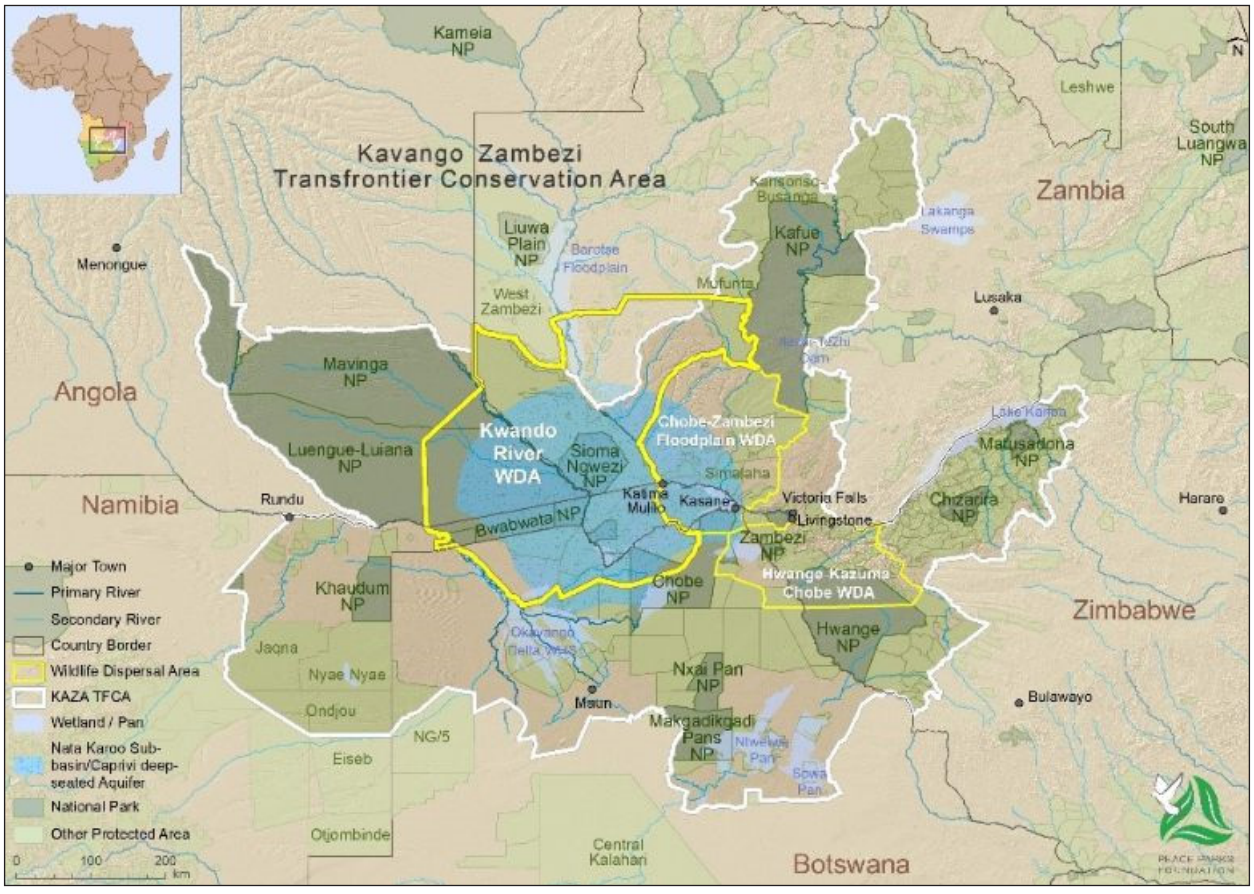

Figure 1 The KAZA TFCA and the Nata Karoo transboundary aquifer is marked in blue, whose exact delineation is uncertain (Source: The Peace Parks Foundation, Villholth et al., 2022).

small-scale livelihoods, form the majority of the population. There are few formal water reticulation systems in place outside major settlements. While surface waters are a critical resource, groundwater and transboundary aquifers (TBAs) are increasingly playing a role in supplying reliable, climate-resilient, and widely available water to dispersed communities and biodiversity. Groundwater also critically underpins natural ecosystems, like rivers, wetlands, and terrestrial vegetation. Addressing the needs and existing gaps in the management of groundwater resources would be vital to supporting biodiversity, economic development, and resilience to climate change in the KAZA TFCA.

TFCAs within the SADC region are not mandated to oversee river basin management, however, they play a complementary role in advancing integrated natural resources management and fostering cross-sectoral collaboration. The SADC Revised Protocol on Shared Watercourses (2000) designates River Basin Organisations (RBOs) with the responsibility for transboundary governance of water resources. However, geographically, river basins, aquifers and associated TFCAs overlap, necessitating the alignment of strategies and actions on water resources by RBOs and TFCAs. In the case of KAZA TFCA, the Okavango River Basin Commission (OKACOM) and the Zambezi Watercourse Commission (ZAMCOM) have jurisdiction over the Okavango and Zambezi River basins, respectively. While there are significant groundwater governance challenges identified in the KAZA TFCA (Table 1), there is opportunity to streamline and improve current governance systems to respond more effectively.

TRANSBOUNDARY AQUIFERS IN KAZA TFCA

The Nata-Karoo is one of five transboundary aquifers in the KAZA TFCA (Villholth et al., 2022). This TBA is shared by four of the five KAZA TFCA countries and referenced in this paper to illustrate cross-country groundwater governance. It is a critical water resource not yet well understood and requires enhanced collaboration and coordination of different actors to ensure sustainable use. As an 'invisible' resource, understanding the hydrogeological dynamics of groundwater is not always straightforward and is further compounded by poor and limited hydrogeological data. This contributes to over-abstraction and even under-use (Cobbing, 2020). More concrete refinement of the Nata Karoo aquifer delineation, and associated groundwater quantities may open up opportunities for transboundary cooperation around the shared resource at both local and international levels. The significant extent of overlap between TFCAs and the TBAs across the Southern African Development Community (SADC) region demands more concerted governance coordination (Figure 2). Table 2 shows the five TBAs in the KAZA TFCA as depicted by the numbers on the map (Figure 2).

RESULTS AND DISCUSSION

MULTI-LEVEL AND CROSS-SECTORAL GROUNDWATER GOVERNANCE IN THE KAZA TFCA

Figure 3 illustrates the polycentric nature of the groundwater governance system in the KAZA TFCA. At the basin level, the two RBOs – OKACOM and ZAMCOM have oversight over shared water resources. At the sub-basin level – the Kwando River (a tributary of the Zambezi River) is of critical ecological and socio-economic importance, particularly for the local communities, for migration of wildlife and for tourism (Bollig & Vehrs, 2021). The Kwando River headwaters originate in Angola where it is considered a 'source of life' and passes through Botswana, Namibia and Zambia. While the Kwando basin is a sub-basin of the Zambezi Basin, some level of cooperation is required at this sub-basin level given the Kwando's ecological significance. A study conducted by the World Wide Fund for Nature (WWF) highlighted the need for data sharing on water quality, and use, as well as common management, and development objectives in the basin (WWF, 2021). Through this project, the Kwando Joint Action Group (KJAG) was formed as a stakeholder consultation platform. Horizontal coordination at this level among RBO technical committees, freshwater working group of the KAZA TFCA, and stakeholder platforms, similar to KJAG could better consolidate management and development actions for groundwater.

Local community based organisations including water user associations, water committees and conservation also require coordination. Within the KAZA TFCA, structures for Community based natural resources management (CBNRM) are already functional and require strengthened coordination across other local level decision making groups as well as vertical coordination to overall basin management. This local-level governance is discussed further later in this paper.

National level groundwater governance

All five countries in the KAZA TFCA have well-developed frameworks for water resources management – national water legislation supported by national water policies. However, groundwater provisions are not uniformly developed to a similar level of detail. Namibia's (ground) water legislation (GoN, 2013) is one of the most detailed in the region, likely due to its arid nature and reliance on groundwater. Sections 56–63 of the Namibia 2013 Water Resources Management Act give detailed provisions on groundwater control and protection addressing areas such as drilling and borehole construction, licensing of boreholes, record keeping, groundwater wastage, and protection of

ISSUES	DESCRIPTIONS
Water scarcity	Southern Africa is classified as having moderate to severe water scarcity for more than half of the year (Mekonnen and Hoekstra, 2016)
Water quality/Pollution	Groundwater and surface water resources in the KAZA TFCA are polluted from various sources, including agriculture, industry, and sewage (Villholth et al., 2022).
Salinity	Widespread salinity in drinking water boreholes in both Zambia and Angola (Interviews with local communities). Salinity increases with the depth of boreholes, signifying a geogenic source of salinity in the study area (Magombeyi et al., 2022).
Borehole Drying	Shallow boreholes are often used to access groundwater for drinking, irrigation, and other purposes. However, shallow wells tend to dry up from August to November, and water becomes turbid during the rainy seasons from January to March (Magombeyi et al., 2022).
Lack of implementation strategies on conjunctive use of surface and groundwater	Ground and surface water management often fall under different agencies, leading to challenges in coordinating conjunctive use strategies. Transboundary guidance for conjunctive use of surface and groundwater resources in the SADC region is limited due to historical focus on surface water (Masemola & Pietersen, 2023; Sauramba, 2022). Local district councils are planning to augment and dilute high saline groundwater with surface water from local rivers (Interviews with local district council)
Climate change	Rising temperatures are expected to reduce groundwater recharge. Additionally, more extreme weather events, such as floods and droughts, are expected to become more common with climate change. Climate change is likely to exacerbate increasing water stress and water quality deterioration (Cumming, 2008). Local communities reported frequent flooding of the Kwando River, which causes damage to crops including damage from wildlife (hippopotamus).
Drought	KAZA TFCA and the southern Africa region are in general prone to drought, and these droughts are becoming more frequent and severe due to climate change. Droughts can significantly reduce groundwater recharge, leading to further depletion of aquifers (Perkins, 2020).
Lack of knowledge on the TBAs	The KAZA TFCA overlaps with five identified TBAs. At the same time, only two of them (the Eastern Kalahari Karoo Basin Aquifer System, and the Nata Karoo Sub-Basin Aquifer System) are presently associated with some level of knowledge although it still remains limited to understand its full extent and hydrogeological formation (Villholth et al., 2022).
Lack of data on and coordinated monitoring in TBAs.	Groundwater monitoring in the KAZA TFCA lacks transboundary harmonization across countries. Further, data collection and sharing are inadequate for transboundary groundwater management hampering informed decision-making and effective cooperation (Villholth et al., 2022).
Lack of natural resource transboundary coordination	Natural resource governance structures are fragmented across several institutions with no clear focus on groundwater (Villholth et al., 2022).
Human-wildlife conflicts	While there is a general co-existence of people and wildlife, some interactions may result in conflict, e.g., at water sources and crop fields. Most communities experience human-wildlife conflict, especially those located close to the Sioma Ngwezi National Park (Villholth et al., 2022). During the dry periods, communities rely on the Kwando River for drinking water, and they encounter conflict with wildlife when fetching water (Interviews with local communities).
Habitat fragmentation	Agricultural expansion and the erection of fences to protect the agricultural activities has fragmented wildlife habitats and isolated populations (Munthali et al., 2018; Nyambe, 2019).
Lack of joint knowledge and data sharing platform and protocol	The lack of a joint groundwater knowledge and data sharing platform in the transboundary aquifers is one of the obstacles to effective transboundary cooperation (Ebrahim et al., 2023).
Groundwater is not typically included in transboundary river basin governance frameworks	All five countries in the KAZA TFCA have well-developed frameworks for water resources management – national water legislation supported by national water policies. However, groundwater provisions are not uniformly developed to a similar level of detail. Priority in monitoring is given to surface water leading to limited understanding of groundwater/surface water interactions (Villholth et al., 2022).

Table 1 Summary of groundwater governance-related issues in the KAZA-TFCA.

aquifers (GoN, 2013). Nonetheless, the Act has not been given full effect, and it is unclear when all regulations contained in the Act will be promulgated (Mapani et al., 2023; Remmert, 2016).

Within the water legislation and policies of the five countries there is general acknowledgement of conjunctive management of surface and groundwater affirming the benefits that accrue from this approach such as improved

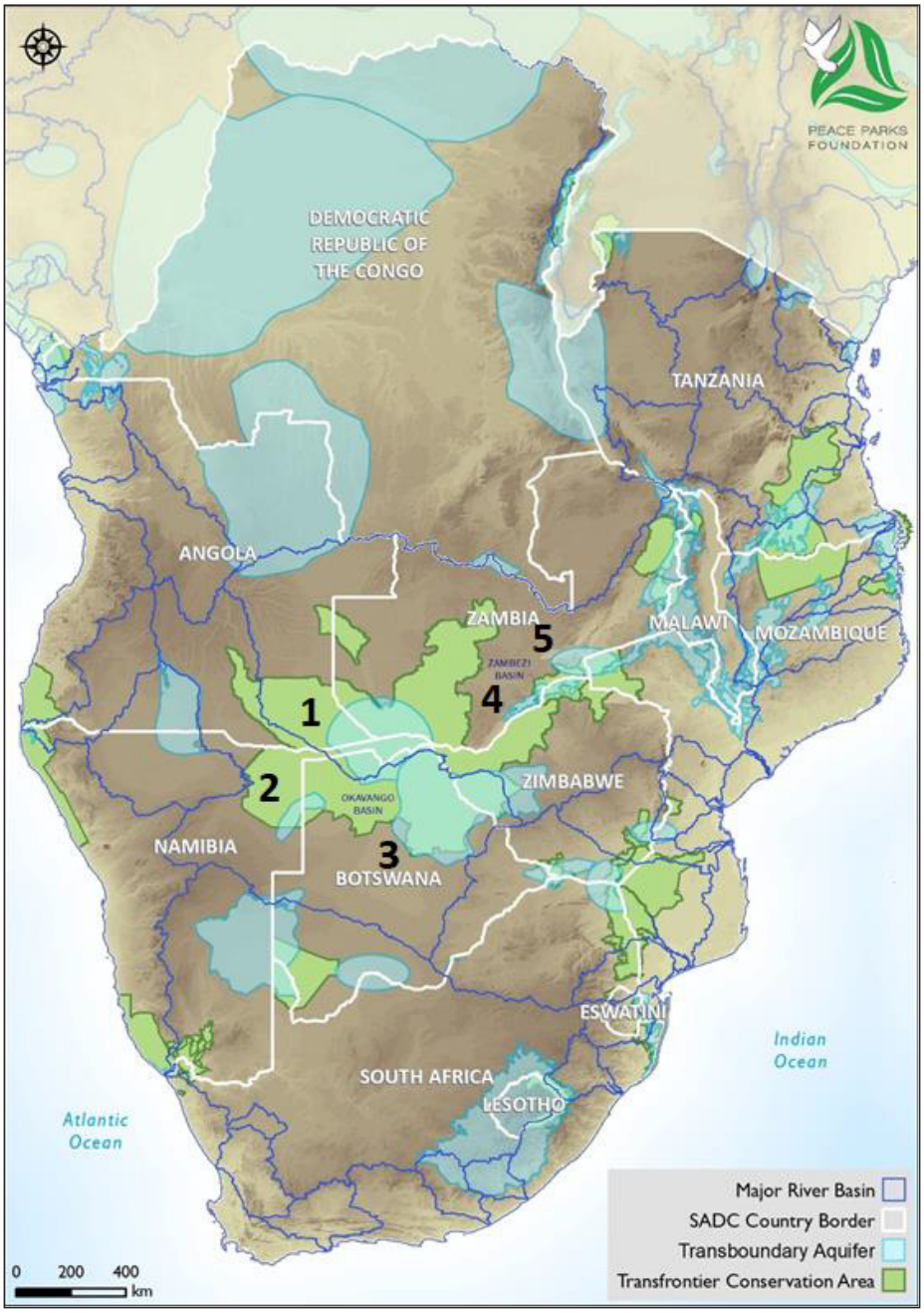

Figure 2 Map of transboundary aquifers (blue) and transfrontier conservation areas (green) in SADC (Source: The Peace Parks Foundation, Villholth et al., 2022).

ID IN FIGURE 2	NAME OF TBA	ID IN GLOBAL TBA MAP (IGRAC, 2022)	COUNTRIES SHARING THE TBA	SURFACE AREA (km^2)
1	Nata Karoo Sub-basin/Caprivi deep-seated Aquifer	AF14	Angola, Botswana, Namibia, Zambia	90,982
2	Northern Kalahari/Karoo Basin/Eiseb Graben Aquifer	AF10	Botswana, Namibia	12,336
3	Eastern Kalahari Karoo Basin	AF12	Botswana, Zimbabwe	127,000
4	Medium Zambesi Aquifer	AF16	Zambia, Zimbabwe	10,705
5	Arangua Alluvial Aquifer	AF18	Mozambique, Zambia	21,235

Table 2 Transboundary aquifers located in or overlapping with the KAZA TFCA (Source: Villholth et al., 2022).

Figure 3 Multi-layered groundwater governance landscape in the KAZA TFCA.

water security and sustainable use of each resource (Lautze et al., 2018; Ross, 2012). Botswana and Namibia currently use several water sources conjunctively, including ground, surface and wastewater (Murray et al., 2021; Perkins & Parida, 2022). However, guidance on conjunctive water use at both the transboundary and national level is lacking, and it is not clear how exactly countries can implement conjunctive management practices particularly at the transboundary scale. Such conjunctive or integrated management of ground, and surface water allows for more adaptive planning for which resource to use, and when – thus responding to climatic variations and allowing resources to recover without reaching critical thresholds (Ross, 2012).

Biodiversity conservation in the vast KAZA TFCA landscape is implemented through several models including forest reserves, conservancies, hunting areas, and game management areas (GMAs), as well as national parks. There are 20 national parks in the KAZA TFCA, and just over 70% of the total TFCA area is under conservation with the remaining portion used for agriculture and rangeland (KAZA TFCA, 2014). Specific conservation parameters apply to the different models – for example, no hunting is permitted in national parks while in the buffer areas of game management areas, hunting is strictly controlled and requires authorization (Bwalya Umar & Kapembwa, 2020). GMAs serve as buffer zones around national parks where communities co-exist with wildlife through community based natural resources management approaches. Across these different models, management plans are developed within the scope of conservation activities, offering an opportunity to integrate the management of groundwater.

At the national level, the Zambia Park management plans primarily focus on conservation and tourism, with a short to medium-term temporal scope. These plans serve as valuable tools for emphasizing the crucial role of groundwater and outline sustainable strategies for its development to support economic activities, water supply for communities, and the well-being of wildlife and ecosystems. In the Greater Mapungubwe Transfrontier Conservation Area, the Mapungubwe National Park exemplifies this approach by actively monitoring groundwater, including tracking abstractions from nearby mining and irrigation farming activities and assessing their potential impact on conservation efforts (Mwenge Kahinda et al., 2016).

Transboundary freshwater governance

The SADC region is ecologically and culturally connected. Through the SADC regional framework for integration, several instruments govern biodiversity and water resources in the shared landscape. The SADC Revised Protocol on Shared Watercourses is inspired by and draws heavily from a global instrument – the 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses (Watercourses Convention). While the Watercourses Convention implies the inclusion of groundwater in the definition of 'watercourses', it does not go further in addressing the unique attributes of groundwater and the implications on its governance. Provisions from the two global regional frameworks have cascaded into basin organisations in the region, including the ZAMCOM and OKACOM. To bridge the gap for groundwater, some RBOs outside of KAZA TFCA have established groundwater technical committees to further enhance attention to groundwater governance. For example, in the Orange-Senqu basin (Botswana, Namibia and South Africa), a Multi-Country Cooperation Mechanism on the Stampriet Transboundary Aquifer System was established in 2017 and operates within the Orange Senqu Commission basin structures. In the Limpopo Basin (Botswana, Mozambique, South Africa and Zimbabwe) the basin organisation – Limpopo Watercourse Commission (LIMCOM) established the Limpopo Groundwater Commission (LGC) in response to the growing need to provide oversight for groundwater development in the basin. The LGC is thus a structure within the LIMCOM basin organisation and has specific oversight of groundwater related activities including groundwater knowledge generation within the basin boundaries. Overall, the committee remains accountable to the LIMCOM.

The 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UN Water Convention) has made great strides in supporting signatories of the Convention to implement its provisions. The Water Convention includes supporting guidance for transboundary aquifers – *Model Provisions on Transboundary Groundwaters* (UNECE, 2014) which offer signatories a more comprehensive framework for the governance of shared aquifers. Among its nine provisions, three stand out as peculiar to groundwater – (i) sustainable management, use and preservation of groundwater-dependent ecosystems (ii) cooperation on the common identification, delineation, and characterisation of groundwater and (iii) cooperation on the integrated management of transboundary groundwaters and surface waters (UNECE, 2014). While the Water Convention does provide a more comprehensive framework for managing groundwater at the transboundary level, it is yet to make traction in southern Africa where Namibia is currently the first and only signatory.[2] Namibia is an arid country, which relies heavily on groundwater and this could have been a motivation for accession. To dispel the confusion that may arise concerning the two global instruments, the UNECE stated that both the Water Convention and the Watercourses Convention are closely aligned to supplement rather than contradict each other and countries can be party to one or both Conventions (UNECE, 2016).

Global biodiversity conservation instruments

Countries in the KAZA TFCA are party to several biodiversity conservation instruments. Out of these instruments, the Ramsar Convention (Ramsar, 2016) is more closely aligned with freshwater ecosystems and provides an important intersection between biodiversity and freshwater governance. Although non-binding, the Ramsar Convention implementing structures are well established in all the KAZA TFCA countries in support of the several RAMSAR designated sites, such as the Okavango Delta in Botswana and the Busanga Swamps in Zambia. Despite clear alignment, no coordination mechanism exists between the Ramsar Convention and the basin organisations. The KAZA TFCA Secretariat, noting the synergies between conservation and transboundary water management went into in a Memorandum of Understanding with the OKACOM to collaborate and share information on common areas of operation including groundwater.

RAMSAR guidelines on managing groundwater (Ramsar, 2016) are an important tool for the KAZA TFCA providing background and supporting information on the linkages between wetlands and groundwater, such as how groundwater contributes to wetlands and the ecosystem services they provide (Ramsar, 2016). This close association between wetlands and groundwater is an important consideration in surface and groundwater interaction and management. It is therefore important to note the overlap between international legal frameworks for freshwater (surface water, wetlands, groundwater), a situation which can benefit transboundary institutions in terms of mutual support. However, this overlap may also be a source of contention in functions if the synergies are not properly defined.

The Ramsar Secretariat closely associates with the UN Water Convention to advance transboundary cooperation on freshwater as well as with RBOs, OKACOM and ZAMCOM, although there is no formal arrangement in place (Ramsar, 2016). International cooperation on conservation and water resources is therefore an important factor in the sustainability of shared natural resources. As there are currently no transboundary Ramsar sites in the KAZA TFCA, there is scope for the addition of such sites, and their integrated management within the KAZA TFCA has to be accounted for, both from a policy and institutional angle

and at the transboundary level. In this case, there potential for the Kwando River Basin, or parts of it, to qualify as a transboundary Ramsar site, as mentioned above. However, it is worthwhile to note that designation of a transboundary Ramsar site does not provide legal status, but a cooperative arrangement reached by countries sharing a wetland. The designation can likely bring attention to the preservation of critical headwaters within the basin.

Local scale practices and decision-making

Starting at the local scale – communal conservancies such as those found in Namibia, the CBNRM approach has received acclaim for its positive outcomes (Kansky et al., 2021; Nelson et al., 2021). Communal conservancies are established by national and local polices and the day-to-day functions are implemented through instruments such as a constitution, benefit sharing guidelines and a wildlife management plan among others. Local and indigenous communities have this landscape as their heritage for generations and continue to draw on the natural ecosystem for livelihoods and have a deep connection with the landscape. Governance structures for natural resources at this local level can better integrate land, water and wildlife. When local communities have the right to manage their natural resources in a collaborative manner with the state and other institutions, this may result in a more sustainable model for natural resource governance (Kansky et al., 2021).

Countries in the KAZA TFCA have largely embraced CBNRM approaches in their conservation policies and implemented through programmes such as the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe (Frost & Bond, 2008) and the Administrative Management Design (ADMADE) for Game Management Areas in Zambia (Milupi et al., 2020). However, the levels of success vary across the region, based on community agency, and perceived benefits to local livelihoods. In such a complex and connected socio-ecological system, integration of groundwater governance may serve to bring a more holistic understanding and management of the natural ecosystem. Through supporting CBNRM efforts across existing structures within the KAZA TFCA Partner States, maximum benefits can be harnessed. Firstly, CBNRM can help strengthen local action by creating strong governance and management structures (Musavengane & Siakwah, 2020). The same structures can be leveraged to promote Integrated Water Resources Management (IWRM) principles – and in particular, the role of communities in groundwater development and management, such as through the existing water committees at village level. There is potential for CBNRM to strengthen local stewardship, gender inclusiveness and accountability at the community level. Moreover, local institutional arrangements for decision-making provide platforms for benefits sharing and regulating access (Adeyanju et al., 2021).

Despite some success of CNBRM, environmental degradation due to activities such as charcoal production and illegal timber extraction poses a threat to habitats within the TFCA (e.g., in the Simalaha Conservancy) (Munthali et al., 2018). Continued sensitization of communities to become stakeholders in environmental protection and conservation management is essential. Payment for Ecosystem Services (PES) may hold the potential to guarantee livelihoods, while sustaining ecological integrity. PES approaches may mean communities receiving proceeds from tourist activities or compensation for damage caused by wildlife (Kansky et al., 2021). Government involvement in PES requires strengthening for it to be successful, for example communities on the Zambian side of the TFCA reported compensation challenges due to delays by government officers in assessing damage caused by wildlife. Further, the success of interventions such as PES depends significantly on the history of the local communities, their relationship with the landscape, and a sense of stewardship and not just the monetary benefits (Kansky et al., 2021). There is potential to explore the value of PES and CBNRM, more broadly in protecting GDEs and groundwater recharge zones. By doing so, communities take responsibility for adopting sustainable land use practices that benefit the sustainable use of groundwater resources.

CONCLUSION

The main objective of this paper was to analyse the groundwater governance regime in a transfrontier conservation context. Considering the increasing role of groundwater in supporting human, wildlife and ecological functions, we found that the integration and coordination of groundwater governance across multiple scales in the landscape is critical. This can be achieved by adapting current structures to harmonise the policy fragmentation across institutions that is currently evident. However, despite the fragmentation, there are notable examples of coordination across the conservation and groundwater resources governance frameworks at the transboundary scale that other TFCAs can learn from. For example, the Memorandum of Understanding currently in place between the KAZA TFCA Secretariat and the basin organisation, OKACOM.

A polycentric approach allows for reinforcement in groundwater governance through vertical and horizontal integration, for example, through joint groundwater planning between TFCAs and RBOs as well as involvement of all stakeholders including local communities in decision

making. While we cannot disregard the effort required for effective coordination across multiple scales, the benefits may well outweigh the perceived bottlenecks. The proposed polycentric approach can ease constraints in three important areas (i) human-wildlife conflict – when there is integrated and consultative planning across scales (ii) consolidating groundwater knowledge on quality and quantity to inform appropriate interventions and (iii) cross-sectoral problem-solving.

To augment current interventions for groundwater governance we propose the following:

- ***Provide guidance on the conjunctive use of ground and surface water*** at the regional level to enhance policy directives in national legislation. A conjunctive management protocol that calls for strong local engagement and adaptive long-term conjunctive management of surface and groundwater resources is a missing component at both the national and regional levels.
- ***Enhance coordination across mandates*** through a KAZA TFCA-RBO-Ramsar Convention tripartite arrangement that promotes the protection of important shared ecosystems and identifies synergies and areas of shared interest for advancing integrated resources management, more specifically freshwater ecosystems (both surface and groundwater).
- ***Maintain and strengthen pre-existing structures*** such as the KJAG stakeholder platform, and the KAZA TFCA freshwater working group, by coordinating with RBO technical committees. Further, to incorporate groundwater technical committees within the RBOs to align groundwater and surface water development planning and foster cross-country cooperation.
- ***Integrate more detailed groundwater management planning*** at park management level (e.g. through establishing groundwater monitoring programs, complemented by dedicated hydrogeological studies in national water departments.
- ***Integrate groundwater management at the local community scale*** into community-based natural resource management frameworks through coordination with local municipalities and national water departments, water user associations, and water committees.

The collective ability to harness and sustain the benefits of groundwater in the KAZA TFCA is dependent on the understanding, informed development, protection, and management of the resource. Limited knowledge on how to sustainably develop groundwater resources leaves both humans and biodiversity vulnerable to the impacts of climate change leading to biodiversity loss and missed opportunities to strategically and sustainably develop groundwater.

ADDITIONAL FILE

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

- **Appendix.** Results. DOI: https://doi.org/10.5334/ijc.1336.s1

NOTES

1 https://kaza-grow.iwmi.org/.

2 https://unece.org/climate-change/news/namibia-becomes-first-southern-african-country-join-un-water-convention.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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