Multiple actor perspectives on sustainable and just water management in South Africa: a qualitative analysis

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Abstract

Post-apartheid South African water policy put sustainable and just water management at the forefront, yet implementation has not been successful. To better understand the reasons behind this gap between policy and practice, we investigated the perspectives of 35 key actors - including government officials, NGOs, academics, agricultural companies, mining organisations, and water service providers - on the barriers and opportunities for implementing sustainable and environmentally just water management in South Africa. Using semi-structured interviews, data were thematically analysed to explore issues related to governance, multi-actor cooperation, policy interpretation, and environmental justice. Findings reveal widespread consensus that while South Africa's National Water Act (1998) is scientifically robust, its implementation is undermined by bureaucratic overload, corruption, and insufficient political will. Respondents identified fragmented governance structures, capacity deficits, and misaligned incentives as major obstacles to policy effectiveness. Public participation was frequently cited as essential yet poorly executed, often excluding marginalised communities. Power imbalances within forums and cross-sector mistrust further constrain collaboration. Despite these challenges, there is optimism about the role of catchment management agencies, community-driven initiatives, and integrated water resource management in facilitating more inclusive and coordinated approaches. The study highlights the need for genuine actor engagement, improved interdepartmental communication, and equitable water access to advance sustainable water governance in South Africa.

1. Introduction

Water, as a fundamental resource, offers a critical framework for examining the links between environmental justice and sustainable development. Its essential role in daily life, from drinking and sanitation to agricultural irrigation and industrial processes, showcases that it affects all individuals, irrespective of socioeconomic status or geographical location (Gleick 1996; Postel 1999). This widespread dependence stems from a complex network of actors involved in water management, including government agencies, private companies, local communities, and environmental organisations, each with their own interests and priorities (Bakker 2010).

Ensuring environmental justice requires addressing disparities in water access and quality, which disproportionately affect marginalised communities (Bullard 1994). Such groups often face greater risks from water pollution and scarcity due to inequities in the distribution of resources and the ineffectiveness of water policies (Pulido 2000). At the same time, sustainable development emphasises the need to meet present water demands without compromising the ability of future generations to do the same. Achieving this goal depends on implementing practices that conserve water, prevent pollution, and protect natural ecosystems, while also recognising the needs of diverse actors (Allan 2001; Rockström et al. 2009). Water management therefore highlights the interconnectedness of human well-being and ecological health, the difficulty of balancing competing interests, and the necessity of equitable policies that integrate both social and environmental concerns (Gleick 2003; Boelens and Zwarteveen 2005).

South African water management is a pertinent case study because it reflects a transition from unsustainable and inequitable resource management to a democratic system that seeks to advance equity and sustainability while involving multiple actors with diverse interests and demands (Megdal 2017; Warner 2005). One of the key tools in the transition was the National Water Act 1998, praised amongst experts for being a scientifically detailed piece of policy (Schreiner 2013). However, the depth of detail and scientific planning within the NWA 1998 created a bureaucratic burden that the Department of Water Affairs could not implement, straining the government's already limited capacity and resources (Pahl-Wostl 2019; Visser and Verhoog 2007).

Fair representation and collaboration among actors improve the effectiveness of water management, but insufficient and ineffective coordination continues to hinder progress toward equitable and sustainable outcomes (Askham and van der Poll 2017; Knüppe 2011; Williams et al. 2018). Conflicts and disparities arise from differing management strategies and unequal access to ecosystem services (Askham and van der Poll 2017; Knüppe 2011). Encouraging participation increases the likelihood of successful collaboration, yet scepticism exists regarding the genuine impact of actor cooperation (Hemmati and Rogers 2015). In South Africa, building trust between the government and citizens through inclusive participation is vital (Blind 2007; Hitlin and Shutava 2022) and aligning different goals and addressing power imbalances are essential for effective water management (Margerum and Robinson 2015; Parrot 2007; Sigalla et al. 2021).

Research has identified key actors in the transition to sustainable water management in South Africa. They include government, water service providers, NGOs, academics, mining organisations and agricultural organisations (Olley et al. 2024). These actors play different roles in shaping water use and pressures. Agriculture, for instance, accounts for 61% of water consumption in South Africa (DWS 2018). Recent advancements in water-saving technologies have improved its efficiency, but overexploitation due to inefficient practices calls for integrated water resource management (Khair et al. 2019; Knüppe and Meissner 2016; Koech and Langat 2018; Masiyandima et al. 2002). The disparity between commercial and smallholder farmers further exacerbates inequities in water distribution (Abraham and Pingali 2020).

Mining has been vital to South Africa's economy, yet it often overlooks social and environmental consequences (Fedderke et al. 2002; van Eeden 2009). Environmental degradation from mining leads to community displacement, health issues, and economic disparities (Down and Stocks 1977; Munnik et al. 2010). Local communities suffer most from inadequate water management, yet community-led initiatives show resilience and innovation (Schoeman and Khorommbi 2007; Williams et al. 2018). Despite the democratic government's mandate to meet all citizens' basic needs, many South Africans, especially in rural areas, struggle with service delivery in sanitation, healthcare, and infrastructure (Moloto et al. 2020). Rural communities face significant water distribution challenges compared to urban areas (Van Antwerpen and Ferreira 2016). At a broader scale, poor service delivery is typically linked to corruption, weak governance, and infrastructure deficits (Odaro 2012). These issues create tensions between rural communities and the government, leading to protests (Williams et al. 2018).

Overall, water management in South Africa is complex, influenced by limited resources, competing demands, and socio-political dynamics. Despite numerous approaches to improve governance, implementation challenges persist, leading to inefficiencies and unsustainable practices. Therefore, the main aim of this paper is to identify and analyse the perspectives of key actors in South Africa's water management, focusing on the complexities and challenges of implementing environmentally just and sustainable practices. It examines the relationships among stakeholders involved in sustainable water management and evaluates their views on navigating and interpreting the NWA 1998. By further understanding the perspectives that influence the work towards achieving sustainable and equitable water management, this work identifies the challenges ahead and the potential for progress towards achieving water security in South Africa.

2. Methods

This study conducted semi-structured interviews with key actors involved in water management in South Africa. Semi-structured interviews employ open-ended questions developed and adapted by the researcher to collect relevant data relating to a subject (Jamshed 2014; Kvale 1994). It involves questions that are somewhat structured but allow the participant to flexibly answer questions depending on their own areas of knowledge (Guest 2013). It is a valuable data collection method as it means that the development of the questions does not exclude unexpected data that may be valuable to the research (Adams 2015).

2.1. Interview design

Key questions were developed (Appendix Table 3.1) based on the major challenges identified in the literature review (Olley et al. 2024).

2.2. Interviews

It was determined that the key actors most directly involved in water management are academics, agricultural companies, government, local communities, mining companies, NGOs and water service providers (Olley et al, 2024). Members from the academia were approached by contacting the authors involved in the publications that arose most frequently in the literature review by Olley et al. (2024). The remaining participants were identified through online searches of relevant organisations, examination of publicly available professional profiles, and recommendations from colleagues with expertise in the field, and were subsequently contacted via email. The interview process was approved by Bournemouth University’s ethics committee (ID: 39783).

An appropriate sample size is dependent on the research topic and the quality and depth of the data collected (Israel 1992). Marshall et al. (2013) proposed that 15 to 30 interviews was an appropriate sample size for a single case study. While this serves as a useful guideline, qualitative researchers generally follow the principle of saturation, where additional interviews provide little or no new information (Mason 2010). In this study, saturation was approached after 35 interviews (Table 3.1).

While complete saturation is rarely attainable, the data collected at this stage were considered sufficient to address the research questions.

Table 3.1. A list of actors, number of participants and their relation to sustainable water management in South Africa

Actor type & number of participants	Relation to sustainable water management in South Africa
Government (GOV, n=6)	Responsible for appropriate management of the nation's water resources and maintenance of its water infrastructure, including dams and pipelines (Meissner et al. 2017; Schreiner 2013; Woodhouse and Muller 2017)
Water Service Providers (WSP, n=7)	Responsible for providing clean and safe drinking water to the citizens of South Africa (Hope and Rouse 2013; Ruiters and Amadi-Echendu 2022).
Mining (MIN, n=5)	Important user of water. Produces acid mine drainage, contaminating water resources and making drinking unsafe (Askham and van der Poll 2017; Chugh et al. 2023).
Agriculture (AGR, n=5)	A dominant user of water. Agriculture is an important industry in South Africa contributing to its economy and its national food security (Chartzoulakis and Bertaki 2015; Malekian et al. 2017; Masiyandima et al. 2002).
Non-Government Organisations (NGO, n=7)	NGOs specialise in access to water and work with local communities to improve access to water. NGOs also pressure the government to act responsibly and manage water resources effectively (Haque 2020; Thomas-Slayter 1992).
Academics (ACA, n=5)	Academics produce valuable research for understanding the complexity of water management (Moglia et al. 2018)

The interviews were conducted between 01/12/2022 and 01/09/2023. Each participant took part in a single interview, conducted one-on-one with the lead researcher via Microsoft teams or Zoom. The interviews lasted between 30 to 60 minutes and were conducted in English. Interviews were recorded using a dictaphone and were manually transcribed. Broader questions were asked (see Appendix 1) and then more focused questions were tailored towards the respondent's area of expertise.

2.3. Analysis

Each interview was transcribed and then imported into NVivo 12. Initial coding involved creating nodes corresponding to preliminary themes derived from the interview guide and recurring concepts in the data. Each transcript was then systematically reviewed, and participants' responses were assigned to nodes based on keywords and themes. Following initial coding, nodes and associated keywords were reviewed, refined, and grouped into broader categories to form the final thematic categories for analysis. This process ensured that themes reflected both the prevalent patterns across interviews and the specific nuances of individual responses. Table 3.2 summarizes the coding process, showing the relationship between initial nodes, keywords/themes, and final categories. For example, nodes such as

“Political will,” “Corruption,” and “Policy” were grouped under Governance, while nodes related to actor interaction were consolidated under Actor cooperation. Other categories, including industry, environmental justice, and water management approaches, reflect the main thematic areas identified in the data.

Table 3.2. Categorisation of keywords into nodes and final categories for the analysis

Initial node	Keywords and themes	Final category
Political will	Lack of progress, Current government, political will	Governance
Corruption	Political interference, Cases of corruption, Government corruption, Impact of corruption	Governance
Policy	NWA 1998, Water Act 1956, Policy interpretation, Water licenses, Compliance with policy	Governance
Implementation	Government capacity, financial restraints, Policy monitoring, Lack of enforcement	Governance
Actor needs	Water uses, Water service delivery, Rural water supply, Water trade-offs	Actor cooperation
Actor engagement	Public participation, Forums, Catchment management agencies, Actor relationships, Power dynamics, Opportunities for decision making	Actor cooperation
Agriculture	Irrigation efficiency, Small-scale agriculture, Co-operation between industry and other actors, Responsible agriculture, Technological advancements	Industry
Mining	Acid mine drainage, Mine closure, Responsible mining, Co-operation with other actors, Impact on local communities, Compliance with policy	Industry
Local communities	Environmental injustices, Rural water service delivery, Representation of local communities, Opportunities for decision making for local communities, Access to services, Community understanding of water scarcity	Environmental justice
Public participation	Current public participation opportunities, Benefits of public participation, Barriers to public participation	Multiple actor participation
Rainwater harvesting	Agricultural rainwater harvesting, Household rainwater harvesting, financial feasibility of rainwater harvesting	Water management approaches
WEF	Energy infrastructure, green energy potential, Interdisciplinary relationship of WEF	Water management approaches
IWRM	Silo governance, Interdisciplinary water management, Potential of IWRM	Water management approaches
Desalination	Desalination potential, Energy expense of desalination, Feasibility of desalination	Water management approaches
Education	Current education projects, Value of education	Water management approaches
SDGs	Monitoring of SDGs, SDGs as a framework, Implementation of SDGs	Water management

		approaches
Water pricing	Water pricing potential, Willingness to pay	Water management approaches

3. Results and discussion

3.1. Multiple actor participation

This part of the study highlights the significance of multiple actor relationships in the context of water management for sustainable development and environmental justice. Numerous actors exist, each possessing distinct demands, uses, and requirements for water resources (Warner 2005). Effective communication and cooperation among these actors are key to achieving equitable and sustainable water resource management (Megdal 2017). This diverse range of perspectives often results in conflicts and disparities in access to the associated ecosystem services and environmental goods, as different ideas and strategies for managing water emerge and present trade-offs (Askham and van der Poll 2017; Knüppe 2011). However, while encouraging high levels of participation and cooperation among actors can increase the likelihood of successful collaboration (Knüppe 2011), some remain sceptical, arguing that collaboration has become little more than a buzzword in sustainable development with limited impact on the ground (Hemmati and Rogers 2015).

Restoring trust and confidence among citizens and communities is important for the South African government, as public perceptions of government actions being aligned with community interests and well-being are central to effective governance (Blind 2007). Establishing trust between the government and the public depends on providing opportunities for participation (Hitlin and Shutava 2022). According to our respondents, the level of involvement of the government and local communities in municipalities can differ considerably, with government consistently identified as the key actor responsible for leading progress toward water security goals. Challenges were frequently attributed to governance issues at the municipal level (WSP7), with inadequate responses to infrastructure problems, such as water leaks, noted by NGO2. Some participants expressed broader concerns about national governance capacity, suggesting that the inability to deliver essential services - including water, energy, and food - undermines public trust in government institutions (ACA2). Overall, the data indicate a perception among respondents that government implementation of water management policies is insufficient.

ACA5 highlighted the role of academics in facilitating cooperation, noting that researchers, through their work, bring together diverse actors and encourage the exchange of ideas: *“The freedom of researchers is that we can facilitate people coming together and slowly sharing new ideas.”* This process could be particularly valuable for water resource management in South Africa, although little research currently exists on this topic. AGR1 reinforced this perspective, emphasizing that research can bridge gaps between actors who often operate in isolated departments, which can hinder service delivery.

The data provide some examples of government collaboration with other actors, particularly in the agricultural sector. AGR2 noted that the government is working with agricultural organisations to enhance irrigation efficiency: *"The government is trying to work with particularly smallholder farmers and improve irrigation for agriculture and these sort of things through the public sector."* In contrast, AGR3 reported instances where government support was lacking, such as following a flood, highlighting the absence of systems to assist farmers with water management. These contrasting perspectives illustrate the ambiguity surrounding the effectiveness of collaboration between government and agricultural actors.

The Sustainable Development Goals (SDGs) have been instrumental in goal-setting and fostering collaboration by raising awareness of shared objectives (Biermann et al. 2022). In South Africa, this has been particularly evident with SDG 6, where actors demonstrate growing interest and commitment to achieving the targets, as noted by AGR2. While shared goals are important, their achievement requires alignment and clarity among actors regarding implementation and management. The SDGs are recognised for promoting collaboration through common objectives (Nonet et al. 2022). Given the complexity of water management, stakeholders view the SDGs as providing guidance and a platform for cooperation, described by AGR5: *"What I love about the SDGs is there are a lot of synergies that overlap. When they overlap, that's where opportunities for action and intervention happen. When you do this, you are not only addressing one goal, but a lot of them."*

Some respondents argued that small-scale farmers are not given the respect they deserve. AGR5 noted that they are often *"spoken down to"* and that other actors assume they *"know what they need,"* despite rural farmers being the ones who *"live this experience,"* highlighting concerns about the prevailing top-down approach to water management. Small-scale farmers occupy a particularly vulnerable position due to a lack of financial resources and power, which limits their decision-making (Woodhill et al., 2020). Risbey et al. (1999) emphasise the need for robust support systems that provide small-scale farmers with access to financial services and social networks. Consequently, it is important that actor groups take responsibility for implementing measures that promote equitable and sustainable water management. Currently, there is a perceived lack of accountability, with AGR5 describing it as a *"blame game"* where *"nobody wants to take responsibility".*

The motivation of all actors influences the success of collaborative initiatives (Davies and White 2012). GOV2 highlighted the challenges of engaging multiple actors in decision-making: *"Take a project that has the potential to impact water resources. The political motive for the project to go ahead, despite its impact on the water resources, is one of the challenges. In most cases in South Africa, the stakeholders, particularly the marginalised ones, are excluded from the project planning process and only get involved once the decision has been made."* Building on this, Biermann et al. (2022) identify insufficient financial resources, lack of political will, and institutional weaknesses as primary causes of failure in SDG implementation. Based on respondents' perspectives, these challenges appear to be similarly relevant in the South African context.

Catchment Management Agencies (CMAs) in South Africa were designed to manage water resources interdisciplinarily and facilitate multi-actor cooperation, operating democratically to ensure equitable water management (Meissner and Funke 2014). However, challenges remain in structuring CMAs with relevant actors, highlighting the need for clearer rules and guidelines (Meissner et al. 2017). Academic and NGO respondents generally view CMAs positively, recognising their role as multi-actor platforms where diverse parties can collaborate for the benefit of water resources and communities. They suggested that CMAs should be localised, with each city or town hosting a platform that brings together departments such as engineering, infrastructure, water quality, health, agriculture, and mining to discuss water protection and best practice. Through collaborative work, these platforms aim to shift value systems and ensure cooperative implementation of water management practices.

Ensuring that water forums contribute to equitable and sustainable outcomes, rather than merely facilitating actor cooperation, remains essential (Biswas 2004). AGR5 noted that this is not yet fully realised in South Africa, as small-scale groups remain disadvantaged relative to larger, financially and socially influential actors: *“There are some commercial farmers' organisations, but those emerging are those who want to be commercial. The small-scale farmers are negotiating to sit at the main table where others are sitting. So, you find out they don’t serve the interest of small-scale farmers.”* Power dynamics within forums persist, reflecting the dominance of large companies in South African water management (Wong 2014). While some authors advocate “anti-firm” strategies, including stronger sanctions, more effective monitoring, and alliances among non-market actors, Wong (2014) warns that framing large companies as “villains” can create divisive dynamics, and suggests understanding the complex interactions among all actors. The interview data indicate a need to address power disparities between large- and small-scale companies, considering socio-economic conditions. Proper identification and inclusion of actors can strengthen the representation of local needs and priorities, as participation promotes transparency and accountability (Neef and Neubert 2011).

Addressing power dynamics within forums requires understanding the roles and positions of participants, as well as the cultural and social contexts that shape their interactions. A nuanced approach is therefore important to include diverse perspectives and experiences, fostering more inclusive and equitable water management community. AGR5 observed that participants are rarely truly neutral and often pursue their own interests: *“You’d think [the forums] represent all these farmers, but when you look closer, it’s mainly what they want to do; they just want to sit at the main table. They don’t want to speak on behalf of [black] farmers, whose struggles and production goals are different.”* This highlights issues of representation in South African water management, reflecting a broader pattern in resource management globally, where governmental and international organisations often hold more power than local communities (Yami et al. 2019). AGR5 further emphasised the need for fairer representation: *“How independent are the forums? They are all human beings with interests who sit in those seats.”* He added that even NGOs may pursue their own agendas, noting the risk of elite capture and questioning who truly participates and whose voices are represented.

These findings highlight the need for genuinely independent actors to facilitate cooperation and ensure equitable participation. The effectiveness of forums in producing actionable outcomes remains debated in South Africa's water governance (Munnik et al. 2016). NGO6 notes the frustration of well-intentioned stakeholders whose discussions *"never seem to translate into action,"* reflecting the broader implementation gap observed in environmental governance (Sundar 2024). Regulatory gaps, weak enforcement, and limited institutional capacity exacerbate these issues (Alicia 2024).

WSP1 is critical of the inclusivity of these forums, arguing that they primarily accommodate individuals connected to organisations like the World Wildlife Fund or municipal water departments, often excluding ordinary citizens directly affected by water management decisions (Reed 2008). Consequentially, these forums, though valuable, naturally exclude particular individuals, usually ordinary citizens who may be directly impacted by water management decisions. In answer, NGO1 proposes a multidisciplinary and local approach to water governance, which is supported by scholars (Pahl-Wostl et al. 2007). According to NGO1, *"That's the best policy, localised, even per city per town, and you are able to have every department (…)on one platform to discuss how to protect the water resource".* This perspective is reflected in the principles of integrated water resources management (IWRM), which puts emphasis on coordination across different sectors and scales (Mitchell 2005). By incorporating diverse viewpoints and expertise, such multidisciplinary forums can create more comprehensive and effective water governance strategies, addressing both technical and social dimensions of water management (Dentoni et al. 2018).

While a localised approach to water governance offers the advantage of tailoring solutions to community needs, it is not without criticism (Vlachos and Braga 2001). Decentralised systems often incur higher costs due to individualised infrastructure and management, whereas centralised systems benefit from economies of scale (Daluwatte and Sivakumar 2021). Their performance also varies widely, shaped by differences in resources, expertise, and local conditions (Leroy 2022). Moreover, without robust policies and multi-level cooperation, local governance may entrench harmful practices, sometimes linked to costly and difficult-to-detect destructive activities (Yu 2014). External pressures such as climate change further threaten effectiveness by depleting community water sources (Daluwatte and Sivakumar 2021).

To summarise, respondents noted that effective water management in South Africa requires stronger collaboration among actors and attention to power disparities, pointing out that existing forums often exclude marginalised groups and rarely translate discussion into action. While actors acknowledged the role of CMAs in facilitating collaboration despite current limitations, many work in isolation, with perspectives limited to their own experiences. The findings suggest that bridging diverse perspectives is essential and that research can play a key role in fostering interdisciplinary collaboration toward shared water management goals.

3.2. Governance

The National Water Act 1998 (NWA 1998) is South Africa's principal water policy and is widely considered one of the most advanced and scientifically detailed globally (Schreiner 2013), yet large parts of the population still face inadequate access to water. Critics argue this results less from flaws in the policy itself than from weak implementation (van Koppen and Schreiner 2014). This section examines actors' perspectives on water governance in South Africa, focusing on factors shaping implementation, including bureaucratic overload, interpretation, corruption, and political will.

Respondents largely supported van Koppen and Schreiner's (2014) view that the shortcomings of the NWA 1998 stem from poor implementation rather than flaws in the policy itself. As GOV4 noted, *"we have some of the most effective water policies in the world. However, it ultimately boils down to the implementation of these policies and their interpretation."* Similarly, NGO2 remarked that *"there are an abundance of regulations, acts, policies, frameworks, strategies and plans (…) they exist in vain if they are not implemented, in most cases they are just a tick-box exercise."*

Research suggests democratic governments often produce more policies than can realistically be implemented (Fernandez-i-Marin et al. 2023), and successful implementation requires adequate administrative capacity (Knill et al. 2024). South African policies face these challenges: the NWA 1998, with its scientific and technological detail, placed a heavy burden on the Department of Water Affairs (Visser and Verhoog 2007). The Act demanded significant resources and labour, both in short supply (Pahl-Wostl 2019). Literature highlights that meaningful reform must be accompanied by clear strategies for effective implementation (Datnow and Park 2012). Respondents echoed this, noting that earlier policies were not necessarily superior but were easier to implement. As ACA3 reflected: *"I don't think the 1956 Act was better than the 1998 Act. I think the implementation of the '56 Act was probably better… Implementation of the '56 Act was done by a bunch of technocrats with a limited view serving the minority of the population. If you just exclude 80% of the population, it makes life much easier."*

Respondents argued that the government was unprepared to meet the NWA 1998's goal of serving all South Africans. ACA4 described the Department of Water Affairs as being in *"a deplorable state, marked by many years of corruption, ineffective leadership, low levels of capacity, and unqualified personnel being appointed to key roles,"* noting the loss of engineers that left the ministry struggling to manage water resources effectively. Similar views across academia, government, NGOs, and agriculture characterised the situation as a *"bureaucratic burden"* and a *"deficiency of expertise,"* echoing Fernandez-i-Marin's (2023) account of overstretched bureaucracies. GOV3 further highlighted the shortage of technical and social science skills, adding that municipalities in remote regions struggle to attract qualified staff compared with urban centres.

Inadequate maintenance of infrastructure was often mentioned as an indication of poor implementation and a lack of political will. South Africa's infrastructure is deteriorating and struggles to meet demand, despite policy commitments to equitable water distribution (Ruiters and Amadi-Echendu 2022). GOV6 noted that insufficient investment, shortages of qualified personnel, and poor maintenance have severely affected water services and infrastructure, with old treatment plants not being serviced and few new

ones built. Respondents from mining, water services, and academia similarly characterised the situation as *"dismal."*

Another factor affecting policy implementation in South Africa is the structural organisation of government, often described as segregated. Scott and Gong (2021) argue the problem lies less in departmental structures than in poor communication between them. ACA4 described government *"silos"* in which each department has its own *"ring fenced budget and [doesn't] operate together."* While ACA5 acknowledged the organisational value of such structures for budgeting, they noted that *"on the ground, it's a different story."* WSP6 similarly questioned the logic of silos, observing that *"every activity whether it is food, energy, influences water so to work in silos is not logical."* Respondents also highlighted the potential of Integrated Water Resource Management (IWRM) to promote shared resource use, with ACA4 emphasising that *"water is a resource that should be used wisely across disciplines."* These perspectives suggest weak interdepartmental cooperation, reinforcing calls to incorporate IWRM principles into intercity water management (Koop et al. 2022). Both academics and water service providers in South Africa support IWRM as a means to overcome current disconnects.

Policy redress requires not only capacity but also political will (Treadway et al. 2005), defined as the collective belief among decision-makers that policy solutions are correct and warrant implementation (Post et al. 2010). Some actors perceive that water managers in South Africa lack genuine commitment to achieving water security. AGR5 emphasised widespread disengagement and a tendency for blame-shifting, highlighting fractured relationships and a need for participatory approaches to build trust and cooperation (Ruiz-Villaverde and Garcia-Rubio 2017). WSP1 similarly observed that the issue extends beyond water, encompassing electricity, refuse, and pollution management.

In contrast, ACA5 acknowledged the presence of capable administrators and governors striving for sustainable, equitable goals despite training gaps and systemic complexity. AGR5 also noted that non-government actors, such as the private sector, often step in when the government underperforms, initiating community-based water projects. WSP1 reinforced this point, observing that initiatives frequently fail due to limited resources and a lack of sustained commitment: *"It's a whole mindset change… which appears to be lacking in South Africa."*

In addition to political will, corruption is a significant restraint on effective policy implementation. Globally, corruption is a primary factor hindering successful policy execution (Kolstad and Søreide 2009), as individuals and groups often seek personal gain from valuable natural resources, and governments may bribe individuals to maintain power, reducing public funds (Kolstad and Søreide 2009). GOV1 highlighted similar dynamics: *"I think that's largely individual resistance by managers who perceive that they stand to lose (...) Some managers perceive that they would be losing power and influence and authority by having certain functions and budgets removed (...) so there's been a lot of resistance and sabotage actually."*

While these perspectives provide a top-down view, challenges from a bottom-up perspective also hinder implementation. End users often struggle to interpret policies, leading to a loss of meaning and reduced

effectiveness (Yanow 1995). Concerns have been raised about the interpretation of the National Water Act 1998 (van Koppen and Schreiner 2014). GOV2 noted that industries face difficulties complying with the Act due to varying interpretations and the need for significant funding to retrofit systems. Academics argue that policies are frequently developed by those with limited knowledge of on-the-ground realities, underscoring the importance of *"ground-up"* policy development that incorporates the perspectives of water managers working directly with the issues (Stefanovic 2019).

Overall, the respondents maintain that South Africa's National Water Act 1998 is a robust policy, but its implementation is hampered by bureaucratic overload, corruption, and inadequate political will. Despite its comprehensive scientific detail, the government struggles due to limited resources, capacity, and poor infrastructure maintenance. Criticism also targets the fragmented structure of government and weak interdepartmental cooperation. Challenges are further compounded by the lack of political will, corruption, and difficulties in policy interpretation by end-users. Overall, respondents agree that the obstacles lie primarily in implementation rather than the policy itself.

3.3 Industry

a) Agriculture

Agriculture is the largest industrial water user in South Africa (DWS 2018). Recent advancements in large-scale agriculture aim to improve water-use efficiency, including micro-jet and drip irrigation, programming irrigation systems, night-time irrigation, and drought-tolerant crops (Koech and Langat 2018; Masiyandima et al. 2002). AGR1 reported that farmers are adopting these strategies. However, increased irrigation efficiency does not always lead to water conservation, as cost savings may be reinvested in more water-intensive crops (Pfeiffer and Lin 2014).

Regarding environmental justice and equitable access, AGR5 noted a *"dual system"* between commercial and smallholder farmers. Commercial farmers *"have the systems in place, they have already been exposed to technology,"* including sensors and probes to measure soil moisture, while such technologies are often too expensive for small-scale farmers. AGR3 highlighted that rural farmers are increasingly using irrigation scheduling and weather forecast platforms, though this remains less advanced than commercial technologies. AGR3 also emphasised literacy as a barrier: *"It's quite difficult for the small-scale grower because 90% of them are illiterate. Most of them don't have smartphones (...) they only rely on one source of weather forecast which is the television."*

AGR2 discusses the practicality of precision agriculture for small-scale farmers, noting that technologies like big data, robotics, and automated systems are feasible in high-income countries (*"when you've got a computer"*) but not viable in low-income, *"base of the pyramid"* contexts. This aligns with theory that modern, commercialised approaches are not always suitable in rural settings and can hinder small-scale farmers' innovation (Eidt et al. 2020), suggesting the need for adaptable solutions for rural communities.

AGR2 also highlights the challenge of incentivising water conservation among smallholder farmers. They explain that most smallholders pay little or nothing for water, so promoting conservation purely for sustainability is difficult. However, linking water savings to cost reductions, such as avoiding wasted fertiliser, encourages farmers to adopt more efficient practices. This aligns with literature showing that farmers perceive irrigation efficiency primarily in terms of crop yield and productivity rather than water savings alone (Knox et al. 2012).

Large-scale agricultural operations often dominate water use, depleting resources and degrading the environment. They hold significant political and economic influence, accessing greater water rights and resources (Abraham and Pingali 2020). Equitable water distribution requires policies that protect water rights, promote sustainable practices, and support small-scale farmers' livelihoods. In Brazil, Wolford (2006) found that large-scale agriculture monopolised land and water, disadvantaging small-scale farmers and rural communities, exacerbating socioeconomic and environmental inequities, and driving deforestation, water scarcity, and pollution. Policies are needed to safeguard ecosystems and ensure fair resource distribution.

Respondents indicate that South Africa experiences similar disparities. Water governance often favours powerful groups, while those with fewer rights or representation are disadvantaged (Joy et al. 2014). AGR5 notes that the economic benefits of water allocation disproportionately favour white individuals, with 98% of water allocated to individuals going to white South Africans. This illustrates ongoing environmental injustice and highlights issues of environmental racism, where inequities occur along racial lines (Darmofal 2012).

When there is the element of custodianship and farmers feel a connection with their land, they are more likely to practice socio-economic and environmental activities (Herman 2015). Farmers who engage with other actors for technical support and education are more likely to adopt water conservation practices, with education level, access to credit, and availability of technical support being significant determinants of adoption (Jara-Rojas et al. 2012). However, the interview data suggests that there is often a disconnect between farmers and other actors when in need of support. AGR3 stated, *"We are not seeing much of the government in the systems in place... [recently] we had a lot of floods and there were no systems in place into water management or into water conservation. They didn't have anyone to report to or to actually intervene in preventing this from happening again."* This highlights the need for greater cooperation between agricultural and other stakeholders, particularly to build capacity in rural areas. Strengthened water governance can support local decision-making and enhance water security (Tapela 2015).

Respondents also noted that, while technological advancements such as micro-jet and drip irrigation improve water efficiency in large-scale agriculture, they do not necessarily lead to increased conservation if farmers shift to more water-intensive crops. Groundwater overexploitation remains a pressing issue, driven by inefficient irrigation and poor policy implementation. Significant disparities

exist between commercial and small-scale farmers: the former benefit from advanced technologies, while the latter often lack resources and capacity, with many smallholders being illiterate.

b) Mining

Some experts argue that the economic value of mines in South Africa has been overestimated, while the social and environmental impacts of mining are largely ignored by mining organisations and government (van Eeden 2009). Mining has long been associated with severe environmental degradation, including water pollution and soil erosion via acid mine drainage (Down and Stocks 1977). These impacts carry social consequences, such as community displacement, health risks, and exacerbated economic inequalities (Munnik et al. 2010). Water sources in catchments near mining operations must therefore be frequently monitored to ensure safe levels for human and ecosystem health (Huang et al. 2010). Consequently, stronger regulatory frameworks and more robust Corporate Social Responsibility (CSR) initiatives have been called for. Similarly, respondents in our interviews describe mining operations as profit-driven and neglectful of responsibility after mine closure. GOV6 observes, *"Mining companies are not doing enough. Water discharged from mines ends up polluting rivers, and underground aquifers without anything happening to the mining companies. Polluter principles...don't cover everyone, or money doesn't solve environmental issues."*

NGO2 gives a detailed account of how they believe mining organisations avoid closure responsibilities for depleted mines (such as pumping and treatment of acid mine water), by transferring them to less-resourced companies, leaving the environmental and social liabilities behind. "*Australian mining company Mentaus exited its liabilities and left South Africa with a R400 million environmental liability. They left us with clusters of open pits, toxic and radioactive dams, unrehabilitated footprints, tailing storage facilities that are unmanaged and partially reclaimed and unmitigated. That of course is a human rights violation".* Many other respondents believe that mining in South Africa unjustly benefits from water resources while negatively impacting availability for others. NGO1 notes, "*Trying to manage the pollution, thousands and millions suffer, for one industry or one corporation...that's not how the value system is supposed to work."*

Interview data indicates that the government is viewed as primarily responsible for enforcing compliance with mining regulations. ACA5 observed that control and enforcement of pollution measures is actually weaker now than in the past. AGR5 emphasises the lack of enforced rehabilitation after pollution incidents, highlighting gaps in accountability and participatory processes. Financial constraints may further limit effective governance. GOV4 explained that insufficient funding for water quality monitoring restricts the government's ability to assess water status across South Africa, given the high costs of chemical analyses and laboratory infrastructure: *"To run a chemical laboratory at every single location would cost billions of rands so government must grapple with what available resources they have".*

MIN3 agrees that mines must plan a closure end state agreed with all relevant actors, accounting for latent and residual impacts, to ensure communities and governments can continue with sustainable post-mining uses. However, they see as the main issue the lack of closure guidance and support from

the government, resulting in significant costs being wasted on maintaining assets that no longer serve a function and could be better used for alternative purposes. To avoid this *"blame game"*, NGO2 advocates for greater accountability from mining organisations, suggesting that sufficient financial provisions should be required before mining authorisation to address both current and future impacts, including water treatment. They emphasize that mining companies must treat water at source and cannot shift the costs of unfit water to downstream users.

Regarding the future of mining, South Africa remains heavily reliant on coal for energy (Mirzania et al. 2023). WSP4 notes this is due to existing infrastructure and managerial capacity: coal is abundant, and the systems to use it are already in place. In contrast, renewable energy would require significant investment, new infrastructure, and skilled personnel (Stapleton 2009), making solar energy *"unaffordable for most households,"* according to WSP4. Mining operations will likely continue to play a central role in the economy, making compliance with legislation, engagement with local communities, and responsible post-closure practices critical. Government oversight is also essential to ensure mining companies protect ecosystems throughout the mining process. MIN3 emphasizes that critical natural resources must be avoided from the start, as they cannot be fully rehabilitated, and careful management of ecosystems from mining commencement through post-closure underpins sustainable development.

MIN1 also discusses responsibility post mine closure, emphasizing the challenges of maintaining basic services: *"Basic services, like sanitation, like drinking water, like power and electricity...when the mine starts delivering those, there is an expectation for that to continue in perpetuity. The mine is not going to be there forever, when it does leave, what will happen to those basic services? And so you create a crippled economy reliant on enterprise or private business as opposed to relying on the state. We must be careful to manage that balance and not get the state off the hook (...) It needs to be done responsibly with the end in mind, which means how can we donate sewage treatment works, infrastructure, potable water, treatment water facilities, and use those in post-mining economies."*

To summarise, Respondents in South Africa express serious concerns about the environmental and social impacts of mining. They argue that companies often prioritise profit over responsibility, resulting in acid mine drainage, pollution, and the evasion of closure obligations by transferring mines to less-resourced firms. Mining actors emphasise planning for closure and pollution avoidance, but other actors remain sceptical that these commitments are being implemented. The government is criticised for weak enforcement and limited resources, reflecting gaps in political will and oversight. Overall, actors call for stronger regulations, increased corporate accountability, and enhanced government monitoring to ensure environmental justice and equitable management of water resources.

3.4. Environmental justice

This section examines challenges in providing services to local communities, environmental justice, perceptions of equitable water provision, capacity building, and public participation. Despite the democratic government's mandate to meet the basic needs of all citizens, including sanitation, education, health care, transport, and infrastructure, many citizens in South Africa still struggle to meet

these needs, particularly in rural areas. Service delivery in rural areas shows few signs of improvement (Moloto et al. 2020) and is often more expensive than in urban areas. Van Antwerpen and Ferreira (2016) attribute this to a lack of competent government officials to implement adequate service delivery. GOV5 highlights the disadvantages faced by rural communities in water distribution: *"In rural areas, the situation is worse because they do not have bulk water systems. Maybe there is a dam in the area, but the pipes are not reaching them, they are passing through some suburban areas or wealthier areas".*

The major contributors for poor service delivery in rural areas globally tend to be corruption and weak governance, infrastructure deficits, human resource constraints and financial constraints (Odaro 2012). NGO1 attributes financial reasons for poor service delivery in rural areas: "*The reason is often because they don't pay very high rates for taxes, (…), they are actually an expense to the municipality, so the municipality services them the least. Then, when they don't have water for 3 or 4 days, they get upset".* This supports Potrafke and Roesel (2020) finding that rural communities are a greater expense to government, leading to lower allocations for necessary infrastructure. The situation is further exacerbated by difficulties in retaining qualified personnel and a general lack of research focused on rural areas, suggesting they are often treated as less relevant (Olley et al. 2024).

Poor service delivery often escalates tensions between rural communities and the government. NGO1 explains that municipalities sometimes send contractors who are not local, leading to harassment and hostility. Contractors are chased away, leaving water systems unrepaired, and in one case, community protests and the burning of a water treatment facility resulted in loss of water access. These conflicts are often linked to broader issues of distrust between communities and government (Williams et al. 2018). Participatory processes that build trust through accountable leadership and capacity development are critical, though they may be hindered in South Africa by a lack of political will (Beer 2014). Engaging communities in decision-making processes fosters trust and improves water management outcomes (Schoemann and Khorommbi 2007; Williams et al. 2018). This view is shared by all actor types. AGR1 emphasizes that when local communities are regarded as primary decision-makers, their effectiveness increases and the likelihood of vandalism diminishes *"as the community assumes responsibility for the management of these initiatives."* AGR1 further notes that empowering communities to develop their own solutions (rather than simply accepting imposed ones) enhances long-term effectiveness.

While most respondents supported public participation in South Africa, viewing it as vital for fair and sustainable water management, some expressed reservations about its practicality. ACA2, for example, questioned whether theoretical concepts translate effectively in practice, noting that the technical complexity of sustainable water management makes it difficult to expect unemployed individuals, struggling to provide for their families, to make well-informed decisions on such matters.

A fundamental question in environmental justice is how public participation can effectively address environmental burdens faced by marginalized communities. Interviews reveal significant gaps in current strategies. ACA2 describes an *"illusion of inclusion,"* where processes appear participatory but fail to

achieve meaningful outcomes, highlighting the need for a more deliberate and inclusive approach. Public participation should amplify the voices of local communities, rather than burden individuals with navigating complex technical issues. ACA5 echoes this perspective, emphasizing the importance of truly listening to these *"unheard"* communities. By providing a genuine platform for input, public participation can better address environmental injustices and align decision-making with fairness and equity.

In contrast to ACA2, AGR2 argues that communities do not need extensive technical knowledge to achieve water security. While simplicity is important, AGR2 emphasises the need for providing farmers with the essential information required to change their irrigation practices and promote sustainability. By focusing on key information, farmers and communities can apply knowledge in their own context, leading to positive changes in water management.

Public participation aims to ensure genuine representation of local communities and minimize bias (Head 2007). It is necessary to determine how typically underrepresented individuals or communities can have their voices heard (Quick and Bryson 2022). WSP7 points out particular challenges for implementing public participation in South Africa: *"Participation is hindered by (…) language barriers, low educational capacity, and poverty. Roads are in poor conditions, which make access (…) impossible. Most [rural] areas do not have access to information communication technology (…) The livelihoods of many South Africans remain below the poverty line; thus, many people are not willing to participate".* Barriers to public participation often include a lack of bureaucratic structure and supportive policies and a lack of awareness of public participation opportunities (Kabogo et al. 2017).

GOV5 recommends that the national government take a leading role in enhancing public participation, directing local authorities to implement targeted measures. While national programs aim to raise awareness and educate communities, it is particularly important to engage those managing water resources at the local level. Currently, communities negatively affected by water management are underrepresented in decision-making, highlighting the need for practical interventions. NGO7 expresses cynicism about public participation in South Africa, noting that opportunities exist but are insufficient, poorly distributed, and constrained by a government-centric mindset: *"I think South Africa has had this attitude that the government must provide. The government unfortunately has reinforced that view, that they are the providers, and the other people must just wait."*

According to AGR5, commercial farmers have greater capacity to organise collectively and negotiate with other actors, which is still a challenge for rural farmers. AGR5 also notes that improved communication between actors has fostered understanding of shared goals and reduced instances of pursuing personal gain. Consequently, there may be a need for a neutral entity to facilitate public participation and discussion in water management decisions affecting multiple actors, though questions remain about whether such entities could remain truly impartial. It is vital to consider the nature of these interactions, the experience of AGR5 suggests that there is also a solely *"top-down approach"* in agricultural forums, where one assumes that they know what is needed based on their own knowledge and experiences. It is important to recognise that the views of those who have an actual lived experience

of an issue at hand and are likely to be more knowledgeable than those who are reviewing the situation externally (Keane et al. 2016).

The interview data highlights several public participation initiatives in South Africa. ACA4 notes that while some NGOs and grassroots activism contribute, most engagement originates from local authorities, particularly around service delivery in low-income areas. NGO6 observes that in some areas local communities have taken proactive roles: "*There have been a couple of smaller towns where the local community has stood up and started doing things and actually taking over. They are fixing the sewage works and cleaning the runoff areas. So, people who are being affected first hand obviously are better to step up than people who hide behind closed doors".* Participation is frequently driven by direct impacts of water scarcity and pollution. NGO1 explains that public engagement tends to emerge reactively, with communities stepping in only after water quality deteriorates and government actions prove insufficient.

Scientific knowledge systems should integrate and value local community diversity and indigenous knowledge through culturally relevant policies (Hamza et al. 2023). Public participation is also valuable for translating indigenous knowledge into practice, which is often overlooked (Williams et al. 2018), and for ensuring effective information flow among all relevant actors (Mabudafhasi 2002). ACA1 emphasizes the importance of incorporating indigenous knowledge into policymaking and leveraging the expertise of local communities to address their unique challenges. WSP2 highlights that information exchange is a key benefit of public participation, while acknowledging the power dynamics inherent in sharing knowledge.

To summarise, respondents highlight significant challenges in water provision and public participation in South Africa. Despite the government's mandate, rural areas face greater service delivery issues than urban areas due to financial constraints and inadequate infrastructure. Poor service delivery in rural areas is often linked to low tax revenue and ineffective municipal management, which fosters tensions, distrust, protests, and vandalism over unresolved water issues. There is broad agreement on the importance of community engagement in decision-making to improve water management, though practical implementation is challenging. While public participation can enhance outcomes if communities are provided with relevant information, barriers such as technical complexity, language, poverty, and limited infrastructure restrict opportunities. Overall, current efforts are considered insufficient and hindered by ineffective government and bureaucratic processes.

3.5. Water management approaches and concepts

This section investigates different ideas and various approaches for achieving water security in South Africa, as perceived by key actors. It examines the practicality of each strategy, the challenges they present, and their potential benefits and drawbacks, highlighting the need for careful consideration when selecting an approach.

a) Rainwater harvesting

Rainwater harvesting (RWH) has been practiced in South Africa for some time but has made little contribution to the urban water supply; by the end of 2019, only 0.1% of Johannesburg's population was using RWH (Ndeketeya and Dundu 2019). Although its implementation is constrained by financial viability, reliability, water quality, and system maintenance (Ndeketeya and Dundu 2019), RWH can still serve as a suitable freshwater source in rural communities, especially in areas with adequate rainfall (Kahinda et al. 2007). The key determinants of success are storage capacity, water quality management, and tank design (Amos et al. 2020). ACA3 suggests the best use for RWH would be as a government programme replacing reticulation, though its potential should be assessed in terms of whether it can provide full services or function as an add-on. AGR1 highlights its value in supporting food security through backyard gardens.

In discussing affordability, GOV5 argues that while the government promises to provide tanks for rainwater harvesting, this rarely happens in practice, and subsidisation is essential. Many rural residents, particularly pensioners, cannot afford the initial costs to establish RWH systems. This aligns with research suggesting RWH may be more feasible in public facilities than in households (Campisano et al. 2017). Studies also indicate that although rural families are willing to adopt RWH, financial constraints remain a significant barrier (Singwane et al. 2013). While RWH can provide water at a lower long-term cost than alternative sources (Amos et al. 2020), actors often perceive it as unaffordable due to high upfront investment. WSP1 illustrates this by noting that a 750L tank costs R2,275, which is comparable to a household's monthly income in some rural areas.

In industrial contexts, however, RWH is already well established. WSP1 notes that most farmers, lacking reticulation systems, rely on rainwater tanks to meet their needs, a finding supported by literature on RWH as an alternative source in water-scarce regions (Velasco-Munoz et al. 2019). Similarly, MIN1 describes how the mining sector uses large open pits to store harvested water, reducing reliance on scarce groundwater in provinces such as North West.

These perspectives highlight the potential of rainwater harvesting (RWH) in South Africa, while also emphasising the significant barriers it faces, particularly affordability and maintenance challenges. Uptake remains limited in households, though it is more common in industrial and mining contexts. Strategic implementation is therefore essential, including assessing where RWH can be most effective and addressing barriers to adoption. Government-funded schemes could play a pivotal role in making RWH viable, strengthening water security in rural communities, and supporting food security. Respondents highlighted the need for subsidies, careful planning, and stronger government support to enhance the effectiveness and uptake of RWH initiatives.

b) Sustainable Development Goals (SDGs)

SDG 6 on water and sanitation provides a useful framework for tackling challenges in the water sector (Cole et al. 2021). This is supported by by ACA4, *"[SDG 6] is something that the national government can use to guide its development agendas."* A key task is identifying indicators that can meaningfully track progress toward sustainable water management, as effective monitoring depends on selecting the most

valuable ones. However, it remains unclear whether “governance by goals” can truly foster collaboration and communication among actors. Furthermore, since the SDGs are not legally binding, progress largely depends on each country’s institutional capacity (Biermann et al. 2017).

While the SDGs can provide useful guidance to governments, interviews reveal uncertainty about how effectively SDG-related information is communicated and implemented. AGR2 questioned whether SDGs reach grassroots communities, suggesting they remain largely confined to national and higher levels. AGR5 highlighted confusion over responsibilities, noting uncertainty about whether participation is mandatory or voluntary and who should take the lead. Although some progress has been made, AGR5 felt that implementation is slow and uncoordinated. Overall, this points to a lack of clear structure for advancing SDG6 in South Africa.

Successful utilisation of the SDGs depends on transparent reporting mechanisms to provide usable data for monitoring progress and ensuring accountability (Doni et al. 2020). From a South African perspective, GOV5 described strong reporting structures, with departments leading their respective sectors and clear champions for different resources, suggesting that SDG reporting is currently well managed. GOV5 also viewed the SDGs as a useful organising framework (*“It's almost been a kind of common language”*) that brings actors together, highlighting their value in fostering collaboration (Beer 2014). AGR2 emphasised the broader value of the SDGs in linking water sustainability to poverty alleviation and zero hunger, noting that while the system can be frustrating, the intention to make progress is clear. WSP6 reflected that although initial uptake was slow, in recent years many organisations have begun taking responsibility. Together, these perspectives suggest that the SDGs are increasingly being used as practical tools for coordination, goal-setting, and impact assessment (Grainger-Brown and Malekpour 2019).

Respondents were generally very supportive of the SDGs, valuing their integrated approach to management and ability to engage stakeholders across disciplines. AGR5 appreciated the synergies between goals, noting that addressing one area often advances progress in others, though emphasising that the real challenge lies in turning commitments into action. WSP5 described how the SDGs have been embedded into government planning and regulation, providing momentum, access to funding, and greater collaboration. GOV5 added that SDG reporting helps identify gaps, which are then incorporated into the national water master plan. However, GOV6 cautioned that political and energy crises are slowing progress, with SDG6 moving forward only *“at a snail’s pace.”*

To summarise, respondents view SDG 6 positively as a framework for improving water and sanitation management, valuing its integrated approach for coordinating efforts and driving progress across sectors. However, concerns remain about its reach to local communities and the clarity of responsibilities for implementation. While some respondents highlight its role in fostering collaboration and attracting funding, others note challenges such as political interference and slow progress. Overall, SDG 6 provides a strong foundation for guiding water management, but its practical impact is limited by communication gaps and implementation barriers.

b) Wastewater treatment

Actors consistently emphasised the importance of wastewater treatment facilities for water security and resource recovery. According to GOV1, investment in maintenance remains a persistent challenge, as local governments, who hold primary responsibility for these facilities, struggle with financing constraints. WSP6 similarly highlighted chronic underinvestment in infrastructure maintenance, particularly for wastewater and potable water treatment, noting that this neglect has persisted for decades but has become increasingly urgent with population growth and rising demand.

GOV3 pointed to the private sector as a potential solution, observing that private wastewater facilities consistently achieve green drop certification due to superior financial resources, technical expertise, and operational efficiency. In contrast, rural municipalities often lack the necessary skills, funding, and administrative capacity to sustain advanced treatment technologies.

Overall, actors identified outdated infrastructure, insufficient maintenance, and untreated sewage discharge into rivers as major risks to environmental and public health. They further linked the decline of facilities to political interference, inadequate investment, limited technical capacity, and the national electricity crisis. While private sector involvement is seen as promising, disparities in management capabilities between urban and rural municipalities remain a central concern.

c) Water pricing

Water pricing has been widely criticised for its potential negative economic and social impacts. Nonetheless, research suggests that it is an effective instrument for promoting water-use efficiency (Akinyemi et al. 2018). In South Africa, however, only 35% of households were paying for water as of 2018. Pricing mechanisms also incentivise more efficient water use in agriculture, and studies show that end users are willing to pay higher tariffs if this guarantees reliable access to water (Chipfupa and Wale 2019).

The willingness to pay (WTP) for water services in local communities, particularly in poorer countries, is a critical factor in evaluating water pricing and achieving sustainable water management. In many less developed contexts, WTP is insufficient to cover the costs of improving substandard rural water services, creating a barrier to meeting development targets (Abramson et al. 2011). This shortfall is largely due to inability to pay rather than a lack of demand, suggesting that alternative financing mechanisms, e.g. such as no-interest loans or payment through unskilled labour, could be viable (Abramson et al. 2011).

ACA1 advocated for the implementation of water pricing, proposing a daily usage cap with automatic cut-off once the limit is reached. Such a mechanism, they argued, would compel households to adopt innovative conservation strategies. The efficacy of water pricing in South Africa has been widely debated, with its primary aim being to promote water conservation. As noted previously, AGR2 emphasised that financial incentives are often more persuasive to farmers than environmental arguments, since immediate cost savings and yield benefits have greater relevance than abstract notions of conservation.

The efficacy of licensing (the juridical process by which rights are granted to individuals or organisations to abstract specified volumes of water from particular sources) emerged as an important discussion point. WSP5 noted that increasing numbers of actors are applying for licenses with modified conditions, abstraction rates, and yields, highlighting the need for careful evaluation. While pricing alone may be less effective as a regulatory tool, licensing requires rigorous and efficient monitoring to ensure compliance. WSP6 discusses the disparities between urban and rural regions in South Africa: *"[informal settlements] are overcrowded, which can result in a lack of understanding of the importance of certain issues. There is also a difference in the level of education and accountability between the middle-class, well-educated areas of the country and the poorer regions. In some cases, people in these areas do not pay for services such as water, which can affect their understanding and reception of the same system".*

In summary, actors emphasised the importance of pricing and licensing as key instruments for effective water management. While pricing has potential to enhance efficiency, its implementation remains constrained in poorer areas where affordability and user engagement are limited. Some actors proposed innovative conservation mechanisms, noting that financial incentives are often more persuasive than ecological arguments. In addition, respondents highlighted the need for rigorous monitoring and region-specific strategies to address management disparities and promote equitable access and use.

d) Desalination

Saltwater desalination is increasingly recognised as a viable strategy for water security, particularly in regions where conventional freshwater sources are insufficient (Curto et al. 2021). Its capacity to provide a consistent supply independent of rainfall makes it potentially reliable supplement to existing resources (Radcliffe and Page 2020).

Nevertheless, the energy intensity of desalination processes, particularly reverse osmosis (RO), raises concerns regarding high energy demand and associated greenhouse gas emissions (Soliman et al. 2021). Research into renewable energy-powered desalination, including wind and solar-based systems, offers possible solutions, though these approaches face challenges such as land-use requirements and complex implementation (Bundschuh et al. 2021). Integration with nuclear energy has also been explored as a means of lowering the carbon footprint of desalination (Soliman et al. 2021). From a policy perspective, GOV3 noted that while conventional water treatment in South Africa currently costs about 6 rand per cubic metre, desalination remains 4–5 times more expensive. However, costs are expected to decline over the next two decades, particularly with the integration of renewable energy sources such as solar, wind, and wave power. GOV3 emphasised that as demand rises and freshwater availability remains limited, desalination will need to be seriously considered in future water supply planning. As a consequence, there is growing support for the feasibility of saltwater desalination in South Africa. As MIN2 explained, *"One has to start rethinking one's view. Yeah, probably five years ago I probably would have said I'm not a big fan of desalination, but it's becoming increasingly prominent and particularly along the coastline is going to be quite expected that we are going to see more developments."* This growing interest is largely linked to the potential of coupling desalination with renewable energy. NGO1

argued that *"when you take into account that it would probably end up being driven 100% by renewable energy in the next 20 years, that can't be an argument [against it]."*

However, enthusiasm for renewable-powered desalination must be weighed against South Africa's current dependence on coal and the limited success of transitions to renewable energy (Mutezo and Mulopo 2021). In addition, NGO5 noted the potential to expand desalination to address acid mine drainage (AMD), observing that while reverse osmosis processes have been discussed for decades, *"nothing has actually come of it. We are going to get to that critical point where somebody is going to push it over the edge and come with a solution."*

In summary, desalination is increasingly regarded as a viable option for addressing South Africa's water security, despite its current high energy demands and costs. Although more expensive than conventional treatment, technological advancements and integration with renewable energy are expected to reduce costs over time. Perceptions have shifted from scepticism to recognising desalination as a necessary intervention, particularly in coastal regions. There is confidence that renewable energy will ultimately drive its implementation, though challenges such as coal dependence and political barriers remain. Desalination is also viewed as a potential solution for treating acid mine drainage, with future innovations anticipated to enhance its feasibility.

e) Integrated Water Resource Management (IWRM)

While IWRM seeks to balance economic, environmental, and social dimensions of water governance, it has been criticised for the gap between its conceptual promise and practical implementation (Cook and Spray 2012). The complexity of integrating sectoral interests, political priorities, and institutional objectives frequently undermines its effectiveness (Wignyosukarto et al. 2021), and the absence of a statutory foundation can hinder enforcement and its integration with land-use planning (Mitchell 2005).

Despite these challenges, IWRM is recognised for its potential to address the multifaceted nature of water management. It promotes stakeholder engagement and supports the harmonisation of traditional practices with modern technologies (Banso et al. 2023). It also provides a theoretical framework for structural coupling between water management and other domains, thereby reducing conflicts and fostering coordinated action (Xu 2023). Furthermore, its adaptability to local contexts offers a system of concerns designed to help communities address their specific water resource challenges (McNabb 2017).

South Africa is often regarded as one of the first countries to adopt IWRM. ACA4 reflected, *"I actually think SA is one of the first people to talk about IWRM and we had some really good progress around the country as a whole."* GOV2 highlighted IWRM's nexus approach, explaining that it enables holistic management of key sectors such as energy, food, climate change, and health, with water as the underlying factor. The establishment of Catchment Management Agencies (CMAs) was intended to facilitate IWRM, and NGO1 emphasised their value as integrated, multi-actor platforms: *"Catchment*

management forums definitely, it's an integrated multi-stakeholder platform (…) Where we are all equal and we are only there for the benefit of the resource of water and the people."

Despite the promise of IWRM, actors indicated it has not been implemented at the expected scale. GOV4 noted, *"I don't think it's at the scale that it should have been implemented at in practice,"* and highlighted the persistence of siloed water governance, where departments operate autonomously with minimal coordination, leading to inefficiencies and missed opportunities. WSP1 supported IWRM across the value chain, including conservation, withdrawal, supply, and wastewater management, emphasising that poorly maintained sewerage facilities currently allow *"well below sub-standard water"* to re-enter the environment. ACA4 further elaborated on the need for integrated urban water management, arguing that water-related departments in cities, covering supply, stormwater, sanitation, solid waste, and energy, often operate independently, with ring-fenced budgets, preventing coordinated management across overlapping areas.

ACA4 highlighted that IWRM has the potential to transform water management in South Africa by framing all water, including wastewater, as a resource that can be reused. NGO1 emphasised that achieving this requires a fundamental change in how water is valued, arguing that *"Water is not valued as much as we value money (…) People's values need to be right to start with and department's, government's, everyone's value system of water needs to be all in the same place (…) If an activity is unsustainable and doesn't protect the water, that activity can't exist."*

GOV2 added that IWRM facilitates localised capacity building, allowing catchment-level management of water, energy, and food systems so that challenges in one region do not affect the whole country: *"Even the energy systems, even the food production, you can break it down into catchments. Different catchments have different dynamics."* NGO1 agreed, highlighting the importance of multi-departmental forums at city or town level, where engineering, infrastructure, water quality, health, agriculture, and mining departments can collaborate to protect water resources, implement best practices, and foster a shared value system around water.

While IWRM is designed to be adaptable, wide-scale adoption remains challenging due to varying societal values, conflicting water demands, and the need for legal and institutional adjustments (Davis 2007; Tkhilava 2015). Inclusion of traditionally marginalised groups, such as women, is also critical, as they bring valuable traditional knowledge to water resource management (Kurup 2020).

GOV2 identified coordination among actors as a major challenge: *"There are so many players in this industry. To co-ordinate that is a huge challenge, and I don't think it's been done effectively".* Nevertheless, GOV2 noted some progress in implementing IWRM values within government structures, citing the development of catchment management agencies that focus on specific regions and bring management closer to communities. Communication remains an ongoing issue: *"There is a block in terms of the flow of information getting to whichever stakeholder needs it."*

IWRM is recognised as a flexible framework that can be customised to local conditions rather than a one-size-fits-all solution (McNabb 2017). Its adaptability is evident in diverse applications, from China's economic and ecological considerations (He et al. 2013) to governance structures in California and France (Davis 2007) and prioritised concerns in Georgia (Tkhilava 2015).

GOV2 also highlighted emerging industry engagement: *"There is quite a lot of interest from institutes like the Water Research Commission, ESKOM is coming into the picture (…) Once we start collaborating and working together we can be able to convince government to start working together in terms of policy development (…) for security for water, energy, food and resilient systems towards climate change impacts."*

In summary, respondents offered diverse perspectives on Integrated Water Resource Management. Many see it as a promising framework that integrates multiple aspects of water management and promotes multi-actor collaboration. Some highlighted IWRM's adaptability to South Africa's complex water challenges, while others emphasised the role of Catchment Management Agencies (CMAs) in facilitating stakeholder engagement, which is crucial for effective management. However, challenges persist, particularly in coordinating stakeholders and translating theory into actionable policy, with communication and institutional coordination identified as major obstacles. Although implementation has been uneven, respondents remain optimistic that ongoing efforts and increased collaboration can enhance IWRM's effectiveness in addressing South Africa's water resource management complexities.

f) The water-energy-food (WEF) nexus

The water-energy-food (WEF) nexus is an integrative framework that emphasises the interdependencies between water, energy, and food systems, noting that actions in one area often impact the others (Li and Zhang 2023). Energy is critical for water extraction, treatment, and distribution, as well as for food production and processing (Zheng et al. 2021). Energy shortages or blackouts can severely disrupt water supply, affecting both availability and quality, with consequential impacts on food security (Guta et al. 2015). WSP7 described how loadshedding in South Africa affects water security: *"Loadshedding disrupt the continuous pumping of water to municipalities and (…) the consumers. [It] also has a negative impact on water quality, when water pressure is increased and reduced in the pipelines".* This experience highlights the importance of recognising the interconnections between water, energy, and food, supporting findings that understanding these interrelationships is essential for informed decision-making and sustainability (Raya-Tapia et al. 2023).

While the WEF nexus is widely recognised, its application at local scales and attention to social dimensions, such as gender, remain limited (Villamor et al. 2018). The interconnectedness of water, energy, and food systems also means that costs or pricing in one sector, such as energy, can affect the others, influencing overall food security (Gulati et al. 2013). Respondent data highlights these dynamics: AGR5 noted the inequities arising from loadshedding, stating that *"those with money can easily move away from loadshedding (…) then it becomes another segregation."* This supports the idea that there is a need to further explore the intricacies that influence the effectiveness of WEF and understand more

clearly which groups are most adversely impacted. This is also supported by MIN5: *“Many areas are unable to fill dams due to loadshedding. This leaves many communities without water”.*

g) Education

Education plays a critical role in water conservation by fostering awareness of water resources and promoting sustainable practices. Education for sustainable development focuses on building competencies that enable individuals to engage in sustainable water management (Rieckmann 2022). More broadly, education enhances environmental awareness and informs policies and management practices, including strategies for efficient water use (Ardoin 2020).

However, education alone is insufficient. Effective water conservation requires integrating technology, policy, community engagement, and legal compliance (Rastogi et al. 2024). As AGR2 emphasizes, technology supports learning, but the core of water education is communication and social interaction: *“In most of those communities (…) the management of water is a very social exercise (…) it’s always interactive, it’s always community based. The biggest missing link (…) is how to provide people with the information and the way to learn a new way of doing things.”* Community engagement also involves fostering responsibility and stewardship over local water sources. NGO5 stated: *“Open sewage goes into this water (…) [but] this water has not only an agricultural incentive, it has a spiritual importance to the people. You’ve got people using these dams which are just sewage ridden and using it to baptise them. Not healthy! So you know [in] this catchment (…) we are working with one of the community leaders, some of the schools and trying to create this culture, to start managing the area. Don’t litter, if you see a sewage break report it, get it fixed. If you see water leaking, report it, get it fixed and start to take some responsibility for your area and then (…) you can have a nice dam to play in (…) but until you start taking responsibility for this it’s not going to happen. It is a slow educational process, that you’ve got to start working on”.*

Another issue raised in education-related questions was the limited opportunities for individuals pursuing careers in water conservation. Respondents consistently highlighted the lack of educational and professional pathways, which restricts broader participation in the sector. There is also a clear need for community-targeted education on waterwise practices. WSP1 emphasizes that limited funding constrains outreach efforts: “*We don’t have lots of resources, but we do as much as what we can (…) A lot more can be done all over. Whether it is government, whether it is us (…) whether it’s neighbours.”* ACA5 identifies gaps in specialized training needed for technical water management: *“You need some expertise to get your pipes, your gravity systems installed. So, there is an issue for the specialist high tech knowledge.”*

4. Conclusion

The equitable and sustainable management of water in South Africa remains a challenge. Successful delivery of this objective is dependent on the collaboration of all key actors. It is important to understand

the perspectives that influence the decision-making of these actors, as well as the obstacles they face and the solutions required to achieve sustainable and equitable water management.

Despite being a comprehensive and scientifically advanced policy, South Africa's National Water Act 1998 faces significant obstacles in its implementation. The respondents have identified challenges such as bureaucratic overload, insufficient administrative capacity, corruption, deficiency of expertise and a lack of political will as major hindrances, which in turn lead to poor maintenance of water infrastructure and inadequate coordination among government departments. Furthermore, difficulties in interpreting policy and the need for a more ground-up approach to policy development have been mentioned as additional challenges to implementation. The findings from this research also emphasise the importance of integrating education and capacity-building initiatives to ensure that all actors can contribute to sustainable water management. Respondents welcomed collaboration, suggesting that by promoting IWRM principles and fostering cross-sectoral partnerships, it may be possible to address these obstacles and enhance the equitable distribution and effective use of water resources in South Africa.

Mining has historically been crucial to South Africa's economy, yet its environmental and social impacts, such as water pollution and community displacement, are often overlooked. The industry has caused significant environmental damage, including acid mine drainage, adversely affecting ecosystems and human health. Despite calls for stronger regulatory frameworks and improved Corporate Social Responsibility (CSR) initiatives, mining companies in South Africa frequently shirk their closure responsibilities, passing liabilities to less resourced entities and leaving substantial environmental harm unaddressed. Respondents highlight inadequate government enforcement and financial provisions as key issues, with widespread distrust in mining companies' commitment to responsible practices. Effective governance, involving actor collaboration and comprehensive mine closure planning, is essential to mitigate mining's adverse effects and achieve environmental justice.

Advances in irrigation technology and crop management have improved water use efficiency, but these efforts do not always lead to water conservation due to economic incentives for water-intensive crops. Groundwater, while not the largest portion of water consumption, remains crucial, particularly in local-scale irrigation. Inefficiencies and policy shortfalls have resulted in groundwater overexploitation. There is a significant disparity in water resource access between commercial and smallholder farmers, with commercial farmers benefiting from advanced technologies that are inaccessible to smaller operations. This inequality extends to water governance, which often favours powerful, large-scale agricultural entities, exacerbating socioeconomic and environmental injustices. Effective water conservation therefore requires integrated resource management, equitable policy implementation, and enhanced cooperation among actors.

Although the democratic government is tasked with meeting basic needs, many South Africans, particularly in rural areas, struggle with inadequate service delivery due to a lack of skilled officials, insufficient funds, and poor infrastructure. These communities face higher service costs and limited access, increasing tensions and diminishing trust in the government. Effective leadership and

accountability are crucial for building trust and improving water management. While community involvement in decision-making can yield better outcomes, obstacles such as language, education, and poverty limit participation. Consequently, community-driven initiatives and activism often arise, highlighting the need for strategic and genuine public participation to achieve fair and sustainable water management.

South Africa is faced with a multitude of water management strategies, each presenting its own set of advantages and disadvantages. Although the practice of rainwater harvesting has been around for some time, it has yet to achieve widespread adoption, mainly due to financial constraints. Wastewater recovery has the potential to enhance water security but is hindered by outdated and poorly maintained infrastructure. Perspectives on saltwater desalination are shifting, with growing optimism about its viability as renewable energy reduces costs. While water pricing is recognised as a means of promoting efficiency, concerns remain about its economic and social impacts. At the same time, IWRM aims to harmonise various aspects of water management but struggles with practical implementation due to sectoral and political challenges. The Water-Energy-Food Nexus is also becoming increasingly relevant, particularly given recent energy issues, though it remains underdeveloped in practice. Finally, enhancing public education on water conservation is essential to strengthen these strategies.

Building trust between the government and communities is key, requiring meaningful participation opportunities. This study emphasises disparities in actor involvement and advocates for a more inclusive policy development and implementation approach. Academics play a critical role in fostering collaboration by uniting actors, facilitating information exchange, and encouraging interdisciplinary research. The success of catchment management agencies (CMAs) and other collaborative efforts depends on addressing power imbalances and ensuring fair representation of all actors, especially marginalised groups such as small-scale farmers. Achieving the Sustainable Development Goals, particularly SDG6 on clean water and sanitation, requires alignment on implementation strategies. This study highlights the importance of multidisciplinary approaches and IWRM for effective water governance, ensuring that forums and participatory processes lead to tangible actions for sustainable water management and the well-being of all citizens. To achieve sustainable water management and ensure equitable access for all, it is essential to address these challenges, improve public education, and promote fair and inclusive policy implementation.

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