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Enhancing water management in South Africa: the need for efficiency in monitoring and evaluation programmes

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Abstract

Water monitoring and evaluation form one of the key components of water reforms in South Africa post-1994. These reforms specifically, seek to improve water management, thus balancing water supply and demand, ensuring water quality and supplying water for the growing population and economy. While numerous laws and regulations, frameworks and institutions such as the Department of Water and Sanitation, the South African Local Government Administration, the Water Research Commission, the South African Association of Water Utilities and South African Human Rights Commission have been set up to meet these objectives, very little successes have been achieved. In some situations, there have been outright failure. These are attributed to overly complexities in the monitoring systems. Furthermore, there is lack of transformation in water management structures as well as insufficient data and information to make inform decisions. This paper uses a participatory data collection approach of qualitative and quantitative methods and extensive literature to explore the complexities of monitoring and evaluating water activities in post-independence South Africa. Our findings uncovered that there is conflicting views between the top-down monitoring approach currently used against a broad participatory monitoring strategy. To address these challenges this paper proposes establishing clear performance indicators, investing in data collection and management systems, strengthening institutional capacity, and promoting stakeholder participation. Additionally, we suggest using innovative monitoring techniques, implementing regular assessments and reviews, enhancing transparency and accountability and integrating monitoring and evaluation into planning processes.

Introduction

Water is a multi-dimensional issue and also a prerequisite for achieving human security at the individual and international levels (Mishra et al. 2021). Having sufficient water is as critical as having good health, safe food, and a sound environment, which are fundamental for human rights universally (Palmer et al., 2018). Considering the intertwined nature of water, it is critical to address water challenges and identify pragmatic solutions through collaboration and collective action (Katusiime and Schutt 2020). Water security is essential for achieving all the Sustainable Development Goals (SDGs), not just SDG 6, as it underpins health, food security, economic (Bengtsson et al. 2015; Adom and Simatele 2024). These authors argue that water security underpins majority of SDGs goals, it guarantees good health (SDG 3), food production (SDG 2), poverty reduction (SDG 1), economic growth (SDG 8), gender equality (SDG 5), climate resilience (SDG 13), sustainable cities (SDG 11), as well as ecosystem protection (SDG 15), making it essential for sustainable development. Consequently, water resources must be managed and governed holistically, systematically and consultatively, ensuring interdependence and collaboration that inculcate technology, innovative institutions and funding across all sectors (Adom et al. 2023). Globally and in particular

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in Sub-Sahara Africa, managing water resources has been taken for granted; many countries across the continent are faced with the menace of management and institutional arrangements in managing national and transnational water basins; water depletion through pollution, environmental degradation and deforestation, lack of investment; infrastructure decay and threats of climate change (Nkosi et al. 2021). Consequently, chronic water scarcity and hydrological uncertainty are some of the greatest threats to the continent's prosperity and stability (World Bank 2023; Wang et al. 2023).

Acknowledging these threats researchers, such as Grison et al. (2023), Bilalova et al. (2023) and Nagata et al. (2022), express that Integrated Water Resources Management (IWRM) is a panacea to address the multifaceted challenges associated with water management across the globe and in Africa, particularly addressing water scarcity and competition for the resources. Similarly, Borchardt et al. (2022) and Fritsch and Benson (2019) expressed that IWRM is grounded on international water law and key principles to addressing cost-effectiveness and knowledge sharing across administrative borders. Furthermore, IWRM is an innovative and technological tool to increase efficiency in water use and a bridge between water demand and availability (Meran et al. 2020). Additionally, IWRM is a means to minimise inequality, raise awareness and education for women, youth and children, and enhance capacity for water management at all levels (GWP and UNEP-DHI 2021).

The central and core principle behind IWRM globally is effectively monitoring and evaluating water resources (Bertule et al. 2018). Makanda et al. (2022), Bertule et al. (2018) and Mgoba and Kabote (2020), defined monitoring in water management as systematic processes to assess, track and improve the efficiency in water-related issues. Palmer and Munnik (2018) also defined monitoring as the continuous collection and analysis of data to grasp the contemporary state of water resources in the form of water quality, quantity, and allocation, as well as the performance of interventions such as infrastructure projects or conservation activities. Klimaitiene et al. (2020) further stated that monitoring entails regular appraisal of key indicators to guarantee that the goals and objectives are adhered to and to identify emerging trends and challenges. On the other hand, evaluation involves periodic measurements to ascertain the totality and efficacy of water management approaches, programmes, and policies (Zhang et al. 2023). It involves analysing the results and the effects of interventions, assessing their sustainability and identifying future lessons and decision-making (Magagula 2019). Similarly, Global Water Partnership (GWP 2021) expressed that monitoring and evaluation are tools used provide insights into the efficiency of a process and its management and assist in reformulating policies and programmes, reallocating resources and guiding processes in a more efficient manner. Furthermore, it promotes transparency and gives civil society and governments a tool to measure performance and the effects of IWRM programmes (Katusiime and Schutt 2020). While monitoring and evaluation are widely recognised as essential components of effective water management strategies globally, many constraints hinder its effectiveness across the globe. Dipela and Mohapi (2021), Sawadogo-Lewis et al. (2022) and Goldman et al. (2024) identify some of these challenges such as limited resources, inadequate capacity building, fragmented management structures, issues with data quality and availability, political interference, lack of stakeholder engagement, short-term focus, complex interactions and feedback loops, insufficient integration with policy processes and complex multi-governance structures. These constraints hinder the development of systems in both government and private institutions to monitor and evaluate spending, improve accountability and implement policies in the global water sector (Adom and Simatele 2024).

Monitoring and evaluation principles and constraints in South Africa are not immune to the global outlook. South Africa's water sector's drive to achieve water security for the population significantly depends on effective monitoring and evaluation programmes. Monitoring and evaluation are integral components of sustainable water management and equitable supply and demand of water resources in the country (Rudolph et al. 2023). Conspicuously, monitoring and evaluation are the bedrock of all policies and regulations enacted post-apartheid in 1994 to address past injustices and unequal distribution and ownership of water resources. Notably among them are the Water Services Act (WSA) of 1997, the National Water Act (NWA) of 1998, the National Water and Resource Strategy (NWRS) of 2004, 2013 and 2020, the Strategic Water Source Areas (SWSAs), Water for Growth and Development Framework as well as Water Infrastructure Development Plans. Weston and Goya (2016) alluded that the key to these policies, strategies and legislation is the incorporation of monitoring and evaluation guidelines to stay up to date on the investments, infrastructure development and mechanisms that measure water quality, quantity and availability of the resources. Adom and Simatele (2022) expressed that stakeholder engagement is paramount and drives the monitoring of water resources in South Africa. Espinoza et al. (2022) mentioned governments, water utilities, civil society organisations, businesses and local communities as key players that ensure transparency

and gather diverse perspectives in monitoring water resources.

Mabizela and Matsiliza (2020), Mabizela and Zwane 2020 and Morkel and Sibanda (2022), are of the view that despite the substantial progress made by the government of South Africa, through the Department of Water and Sanitation and other water bodies to enhance water management through globally recognised frameworks and models in monitoring and evaluating the water resources in the country, however, it appears to have fallen short of achieving the desired outcomes. This is evidenced by persistent water quality issues, high levels of pollution, service delivery protests, persistent water interruption, communities' dissatisfactions, infrastructure breakdown, data quality issues, lack of accountability, high levels of corruption, funding gaps, environmental degradation and discrepancies between policy intentions and implementation challenges. In an attempt to address these challenges, many scholars and policymakers have explored different strategies for improving water management in South Africa; outstandingly, Adom and Simatele (2024) considered strategies for overcoming policy implementation challenges to meet water security in South Africa. These authors expressed that there should be a coordinated approach to addressing water challenges in the country. Rosenberg et al. (2020) explored monitoring and evaluation in a changing world and proposed a broader conception and understanding of the phenomenon, while Mthethwa and Jili (2016) investigated the challenges in implementing monitoring and evaluation within local municipalities in South Africa. However, many of these studies on water resource management tend to overlook the critical role of institutional management, particularly the involvement of stakeholders in monitoring and evaluation processes. There is a noticeable gap in the literature regarding how institutions coordinate water resource management, ensure participatory decision-making, and integrate diverse stakeholders such as government agencies, local communities, NGOs, and private sector actors into monitoring and evaluation frameworks. Additionally, limited attention is given to the use of data-driven approaches in these processes, which are critical for making informed, adaptive, and sustainable water management decisions. Given these gaps, this paper assesses the effectiveness and contextual importance of monitoring and evaluation frameworks in addressing the complex challenges facing the South African water sector under these three main objectives: (i) comprehensive assessment of the strengths and weaknesses of the current framework of monitoring and evaluation in water management (ii) factors hindering monitoring and evaluation in water management (iii) enhancing monitoring and evaluation of South Africa's water resources through an integrated management approach.

Monitoring and evaluation of global and South Africa's water management systems

Globally, water management entail the process of planning, developing and managing water resources in a manner that achieves both quantity and quality across all sectors (Julio et al., 2021). Key drivers of water management include building strong institutions and sustainable infrastructure, providing incentives and information that support and guide water management and broader participation of all players (George-Williams et al. 2021). Similarly, Loucks (2021) expressed that water resources management strives to harness the benefits of water by ensuring an abundance of water with the right quality for drinking and sanitation purposes, food production, energy generation, inland water transport, and water-based recreational activities, as well as sustaining healthy water-dependent ecosystems and protecting the aesthetic and spiritual values of lakes, rivers, and estuaries. Water resource management also involves managing water-related risks, including floods, drought and contamination (Mishra et al. 2021). Achieving the complexity and strong connection between water for households, economic development, and ecosystems requires effective monitoring and evaluation mechanisms built on synergies and trade-offs between water withdrawal and supply across the globe (Matchaya et al. 2019).

Evaristo et al. (2023) also stated that strengthening water management against increasing demand, and climate change requires effective monitoring and evaluation at all levels. Fundamentally, monitoring plays a critical role in understanding where to focus investments, what is working and what is not, why this is the case, how to learn from the past, maximise impacts and build a strong future (Dwivedi 2021). Similarly, Mosweu and Rakemane (2020) expressed that monitoring is critical for good management as it provides feedback on the effectiveness of policies, programs and strategies. It also allows governments and management to identify successes and areas for improvement, thus enabling service providers to adjust their strategies and ensure that resources are used most effectively. Bhatt and Chaloraborty (2021) further posited that monitoring provide opportunities for public services to measure cost-effective and equitable delivery, allowing governments to identify and address any disparities in accessing services dedicated to the community. It also serves as a means of assessing the effectiveness of strategies and initiatives,

ensuring that resources are used most effectively (Gandrita 2023).

Evaluation on other hand, helps in identifying aspects of a project or activities that are most important to the overall success and which elements should be prioritised (Abad et al. 2021). It also serves as a tool for measuring progress, thus helping to ensure that objectives are met and resources are used wisely. Additionally, evaluation provides insight into where changes are required to enhance performance and increase efficiency (Kabonga 2019). Similarly, Brown et al. (2018) posited that organisations are guaranteed to use resources to achieve the desired results effectively through evaluation. Nilashi et al. (2023) also expressed that evaluation processes enable organisations to gain necessary data and information to make informed decisions, set goals and track the progress of development activity. It further provides the necessary means to assess the overall performance and make meaningful changes that can positively influence outcomes (Reed et al. 2021).

Globally, monitoring and evaluation programmes are built on two main recognised framework: The Elinor Ostrom's Social-Ecological Systems (SES) Framework and Advocacy Coalition Model. The SES provides a valuable lens through which to understand and monitor water resources in globally including South Africa (Biggs et al. 2022). This framework according to Fallon et al. (2022) provides a comprehensive tool to measure water distribution challenges and availability within countries. Nagel and Partelow (2022) identified the key components and measurable variables of SES framework to include, water sources (Resource System), water availability and distribution (Resource Units), governance structures (Governance System) and users (Actors).

The Institutional Analysis and Development (IAD) of the SES framework, depicted in Fig. 1, provides a structured approach in the monitoring and evaluating environmental resource management. These involve integrating ecological systems, governance structures, and stakeholder interactions. On the left, Resource Systems (RS) such as rivers, forests and Resource Units (RU) (e.g., water volumes, fish stocks) interact under Ecological Rules (ER). While on the right, Governance Systems (GS) (e.g., water agencies, policies) regulate Actors (A) (e.g., farmers, industries, NGOs), creating feedback loops. At the centre, Focal Action Situations define interactions (I) that lead to measurable outcomes (O), forming the monitoring and evaluation zone. The process follows four key steps: (1) Identifying Resource Systems and Units by assessing ecological conditions and key indicators, (2) Assessing Governance and Actor Participation by reviewing policies, stakeholder roles, and enforcement, (3) Monitoring Action Situations to track

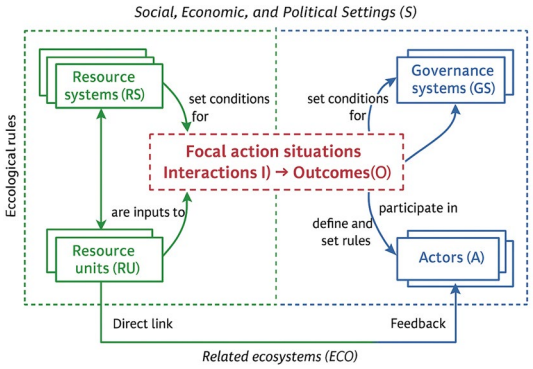

Fig. 1 The Elinor Ostrom's Social-Ecological System Framework. Source: SES Library and the International Journal of the Commons

policy effectiveness and stakeholder interactions, and (4) Evaluating Outcomes and Adapting Policies based on collected data to refine governance strategies. Figure 1 conceptualises the applicability of the SES framework.

The Advocacy Coalition Framework (ACF) is another tool used to monitor and evaluate water and environmental resource in most countries Osei-Kojo (2022). The Advocacy Coalition Framework (ACF) explains policy change as a dynamic process where competing advocacy coalitions, composed of government agencies, NGOs, industry groups, and researchers, operate within a policy subsystem to influence decision-making (Nohrstedt et al., 2022). As illustrated in Fig. 2, the external system events, such as economic shifts, environmental crises, technological advancements and political changes, create windows of opportunity for policy change by shaping conditions within the policy subsystem. Within the sub-system, multiple coalitions with shared beliefs leverage resources and strategies, including scientific research, media influence, lobbying groups and legal action, advocate for their preferred policies. The Central to this framework is the role of monitoring and evaluation processes, which serve as a mechanism for policy learning and feedback loops. The monitoring generates empirical data which the coalitions use to refine their arguments, challenge opposing perspectives, or strengthen their advocacy efforts. The regular monitoring and evaluation reports provide evidence on policy effectiveness, environmental conditions, and socio-economic impacts, allowing coalitions to adjust their strategies and policy demands. The policy brokers, such as government agencies and independent evaluators, use the monitoring and evaluation insights to mediate conflicts between coalitions and facilitate more informed decision-making. Over time, policy learning driven by monitoring and evaluation findings leads to adjustments in coalition

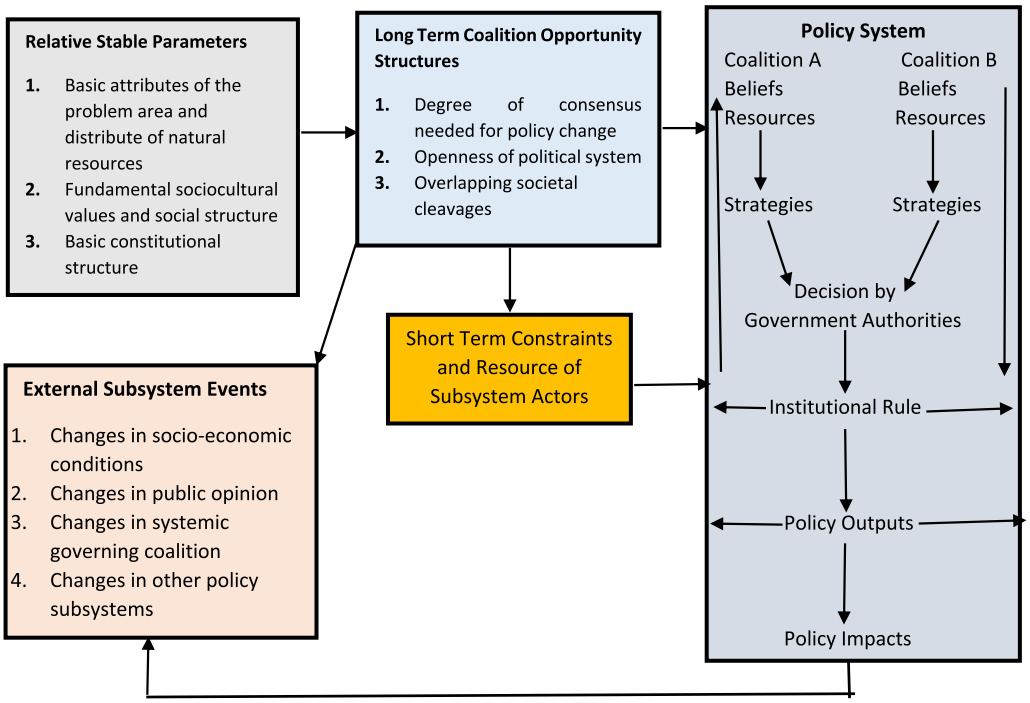

Fig. 2 The ACF of the monitoring and evaluation processes in global water management. Source: Theories of the Policy Process" (5th Edition, 2023) edited by Christopher Weible and Karin Ingold

beliefs, strategic shifts, and, ultimately, policy change. When a dominant coalition gains enough influence mostly due to external shocks or accumulated monitoring and evaluation-driven learning—policy shifts occur, either through incremental improvements based on evaluation data or major reforms triggered by crises revealed in monitoring reports. Figure 2 demonstrate the working trend of ACF.

Globally the applicability of these frameworks by a country in monitoring and evaluating its water and environmental resources depend on the dynamic landscape characterised by technological advancement, human capital availability, policies and regulations as well as the desire to meet the Sustainable Development Goals (SDGs) agenda 3, 6 and 13 (Evaristo et al. 2023). Peletz et al. (2018) disclosed that majority of the developed countries, mostly in the global north, particularly Australia, the United States of America, the Netherlands, Germany, Singapore, Sweden, Denmark, Canada, and Israel have achieved greater successes in monitoring and evaluating water management using these frameworks. Osei-Kojo et al. (2022) identified factors such as sufficient financial resources, well-established infrastructure, technologies and availability of human capital serving driving tool to these successes. Furthermore, Khoffi et al. (2025) stated that robust institutional capacity, comprehensive data availability, stringent regulatory frameworks, investment in research and innovation and international cooperation and support have propelled most developed and advanced economies to apply SES and ACF frameworks in the monitoring and evaluating systems their water management.

In the case of South Africa, while monitoring and evaluation of water resources not directly built on SES and ACF works, however, they align closely with principles and practices of the frameworks (Khofi et al. 2025). The SES whose underlying principles entail decentralisation and multi-stakeholder governance of the environment allied directly with National Water Act (1998) which established Catchment Management Agencies (CMAs) and Water User Associations (WUAs) (Meissner et al. 2016). Weston et al. (2016) argue that the Ostrom's concept of polycentric governance and nested institutions promote localised decision-making and cooperative governance. Additionally, Lukat et al. (2022) stated that the South Africa's Integrated Water Resource Management (IWRM) approach mandates participatory decision-making, these also align with the framework of SES which stresses on stakeholder involvement in shaping policies. Similarly, Funke et al. (2020) and Ndeketeya and Dundu (2022) stated that South Africa water management structure also link well with ACF guidelines, where advocacy coalitions involve civil societies, businesses, and policymakers, influencing

policy evolution, shifting from supply-driven to demand-driven management approach. The country's iterative policy reviews, adaptive management strategies, and institutional learning processes, such as the periodic revisions of the National Water Resource Strategy (NWRS), buttresses the SES's and ACF's which stress feedback-driven policy adjustments (Pollard et al. 2023). Moreover, monitoring and evaluation systems promote conflict resolution mechanism through institutions like the Water Tribunal, enabling equitable resource distribution and reinforcing evidence-based advocacy ideologies similar to principles of SES and ACF.

Despite aligning closely with SES and ACF's ideologies, very little success has been achieved in the monitoring and evaluating the country water resources (Khoffi et al. 2025). Numerous researchers such as Viljoen and Bosman (2018), Rosenberg et al. (2020), Shongwe and Meyer (2023) and Kahinda et al. (2022) argue that monitoring and evaluating of South Africa's water resource is fragmented with isolated functions and responsibilities among various agencies. Jenkins-Smith et al. (2018) expressed that ACF model for instance is too literal and foreign for South Africa's water management context. Wesche al. (2025) and Muller (2012) stated that the frameworks have failed to account for the country's complex governance structures, historical inequalities, informal water management practices, resource constraints, data limitations, cultural differences, and political interference in water management all of which require more context-specific approaches. Kahinda et al. (2022) argue that the Department of Water and Sanitation controls the monitoring systems that collect the relevant data and information and that the systems were developed largely in isolation from one another hence, the coverage is incomplete; consequently, little or no information is collected in most areas of the country. Kahinda et al. (2022) further stated that serious challenges also lie with the quality and reliability of information. This author expressed that in most situations, the data collected by some institutions from national government departments, provincial and local governments, water boards, private organisations and water users are inconsistent and unreliable. Furthermore, Adom et al. (2024) posited that interwoven structural, and systemic constraints hinder the monitoring and evaluation systems in the country. The limited and dilapidated infrastructure, budget constraints, capacity challenges, fragmented management, policy and legal framework weaknesses, data management issues, political interference, historical inequities, lack of public participation, and climate change impacts as significant constraints to effective monitoring and evaluation of water services. Hassenforder and Barone (2018) also state that inadequate funding arrangements are major factors. According to this author, a significant hindrance to monitoring and evaluation is the adequacy of the enabling environment under which water resources are managed at local, national and intercountry levels. The current institutional structures are often inadequate, and the financing of investments is often unsustainable (Bocken and Short 2021).

Materials and methods

Assessing and understanding the complexities of water monitoring and evaluation in South Africa requires a comprehensive research methodology that integrates multiple perspectives. Hence, this paper employed a participatory approach to explore the subject matter.

The study site

The data for the study was collected from four provinces of South Africa, namely, Gauteng, KwaZulu Natal, the Free State and the Eastern Cape, as a case study for the entire country. See Fig. 3. The colours and percentages indicate water security indexes in each province of South Africa calculated, using National Water Balance Model (NWBM) of 2020, used by the DWS to track water availability, demand, and supply at a national level.

The choices of these provinces were informed by their strategic geographical location, the socioeconomic factors and infrastructural development that influences water management. Moreover, the low reliability of water supply in these provinces also influenced the selection process, as consistent access to water is critical factor in decision-making. Additionally, the provinces offer pragmatic insights into the complexities and dynamics of water management in the context of urban, rural, and coastal environments, replicating the diversity in population distribution, economic activities, and occupation, which are key features of decision-making in water management. Specifically, Gauteng was picked due

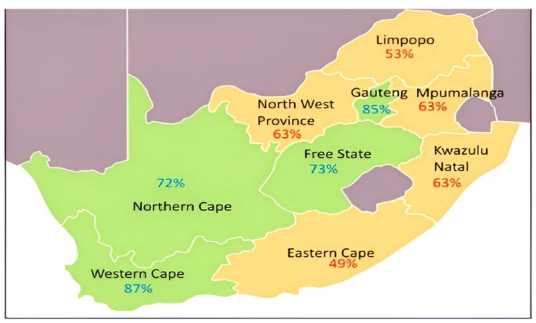

Fig. 3 A map of South Africa with reliability of water supply. Source: Department of Water and Sanitation 2018

to its urbanisation and industrialisation characteristics and its huge water consumption trend; Free State and KwaZulu Natal were selected due to their strong link to agricultural production. These two provinces together provide approximately 40% of the entire food consumed in South Africa. Furthermore, KwaZulu Natal is noted for its climate variabilities and endowed with abundant water resources, including major rivers like the Tugela, Umgeni, and Umkhomazi, as well as extensive coastal areas, while Eastern Cape was selected because of the combination of its urban, rural and coastal setting, high levels of poverty and historical water development pattern.

Research design

This paper utilised triangulated research method namely: qualitative, quantitative and secondary approach to explore the systemic, structural and institutional challenges to monitoring and evaluation of water resources in South Africa. Figure 4 summarises the research design.

Specifically, extensive literature content supplemented by the concurrent mixed method of quantitative and qualitative methods were used to explore the factors retarding effective monitoring and evaluation of water resources in South Africa. The literature materials in the form of book chapters, journals, research papers, minutes of meetings and government gazettes were used to explore the policies, regulations and processes involved in managing water monitoring and evaluation in the country. The qualitative method mainly in the form of interviews were extensively used to explore the systemic, structural and institutional impediments to the monitoring and evaluation processes in the country, while the quantitative approach in the form of questionnaires was extensively used to gauge the levels of satisfaction among the population on the manner monitoring and evaluation activities are carried out in the country. These methods were used simultaneously between May to November 2024.

Sample population and sampling technique

This study used a purposive sampling approach to select a total of twelve respondents from selected government institutions and private organisations for face-to-face interviews. The sample size was determined using a combination of thematic saturation for qualitative interviews and statistical adequacy for quantitative questionnaires. For the interviews, the 12 respondents were purposefully selected based on their expertise and experience in the water sector management and diverse perspectives in maintaining analytical depth. This aligns with qualitative research standards, where 10 to 20 interviews are typically sufficient to capture key themes before reaching saturation. For quantitative approach, the sample size was chosen to ensure statistical reliability, considering factors such as population size, estimated response rates, and the need for meaningful data comparisons. This combined approach ensures a balanced and rigorous methodology, leveraging both qualitative and quantitative data to provide a comprehensive understanding of the monitoring and evaluation processes in South Africa's water sector. In terms qualitative approach, two respondents each were selected from the Department of Water and Sanitation from Gauteng, KwaZulu Natal, Eastern Cape and Free State. Two respondents were also picked from the

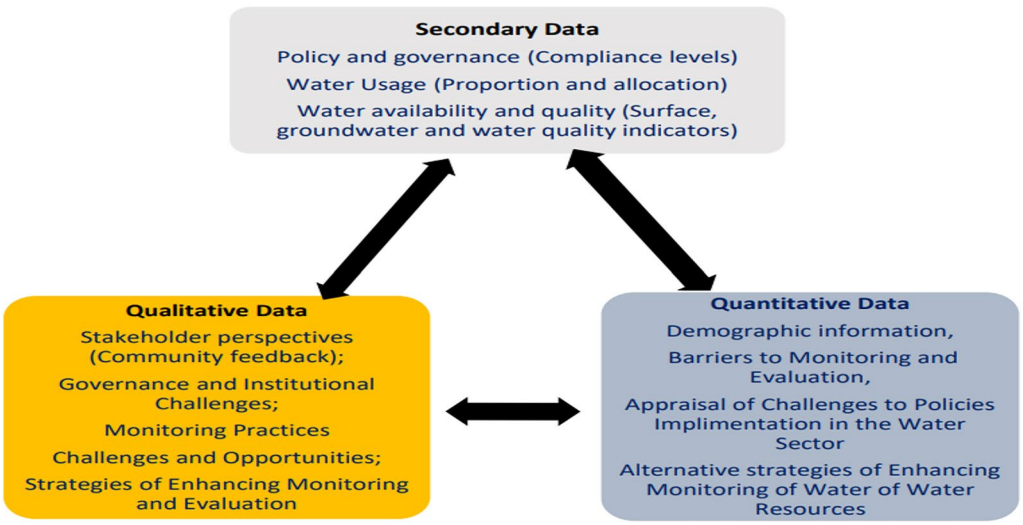

Fig. 4 Summary of the research design

National Department of Monitoring and Evaluation; one respondent was selected from Water Research Institute Rhodes University at Graham, as well as a respondent from an International Water Management Institute (IWMI) representative in Southern Africa in Pretoria. For the quantitative data, a random sampling technique was used to receive 300 out of 500 questionnaires distributed to respondents in ten communities in the same selected provinces. The majority, 70%, of the questionnaires were disseminated online in the form of email, social media, and website integration. The remaining 30% were distributed directly by the researchers together with the field assistant.

Data collection methods

The study made use of existing data from journals, academic books, articles, and government publications. Data were also collected concurrently using face-to-face semi-structured interviews as well as open-ended and Likert Scale Questionnaires. According to DeJonckheere and Vaughn (2019), the face-to-face semi-structured data collection method is a flexible but guided method, integrating predetermined questions with the freedom to explore in-depth responses and adapt the interview flow based on the participants' responses. This approach was used extensively to establish insights into the strengths and weaknesses of existing monitoring and evaluation frameworks in the water sector. Additionally, the method assisted in obtaining data to address the capacity gaps, weaknesses in coordination among key institutions and role-players, conflicting responsibilities and dearth of support for monitoring and evaluation programmes. The questionnaires were used to measure the levels of satisfaction or dissatisfaction with monitoring and evaluation activities among the population and the level of support for various initiatives or interventions programmes. It was also used to solicit data in measuring levels of effectiveness and implications of monitoring and evaluation programmes in the water sector. Prior to data collection, ethical clearance was obtained from the relevant institutional review board. All participants were informed of the purpose of the study and their rights, including anonymity, confidentiality, and voluntary participation. These principles were strictly observed throughout the research process.

Data analysis and interpretation

Both the primary and secondary data obtained were analysed simultaneously using different analytical tools and techniques. The qualitative data from the interviews were analysed using a thematic and constant comparative analysis approach. According to Yeung (2022), these techniques are two distinct approaches but work together to address a research study's specific objectives and provide valuable insights into complex social phenomena. The thematic analysis encompasses identifying, analysing and reporting themes within qualitative data; on the other hand, constant comparative analysis systematically compares data within and across cases to identify similarities, differences, and patterns (Naeem et al. 2023). However, these techniques were used concurrently to transcript, code and group data into broad themes for analysis and interpretation. The secondary data were analysed using content analysis, which involves methodically classifying and analysing documented data to identify patterns, trends and relationships for easy interpretations. The quantitative data were analysed using Statistical Package for the Social Sciences (SPSS) version 22 software. This software was used to convert data into frequency tables, graphs and diagrams. The diagrams, tables and graphs assisted for quick interpretation and comprehension.

Empirical evidence

The analysis was structured based on the three main objectives of the paper, which include assessment of the current framework guiding monitoring and evaluation of the water sector, structural, systemic and institutional hindrances to monitoring and evaluating water management and strategies of enhancing water monitoring and evaluation in South Africa.

Demographic background of respondents

The demographic background was deemed important in this research as it provide diverse perspectives and equitable representation in monitoring and evaluating water resource management practices in South Africa, given the country's socio-economic and environmental disparities. Table 1 reflects the background of the respondents.

The outcome from Table 1 reveals a diverse group of the 300 respondents, with a nearly balanced gender distribution. Out the total responses received 160 equating to 53% were males, against 140 or 47% females. Majority of the respondents were in the age group of 25–34 years 105 (35%). A larger portion of the respondents are well-educated, with 50% of them holding at least a bachelor's degree or higher. Geographically, the respondents are slightly more urban-based (50%) than rural (40%). The income levels are broadly distributed, with most individuals falling within the low to upper-middle income brackets, while 20% earn high incomes. A majority are married (70%), and employment is primarily concentrated in the government institutions (42%), followed by the private sector (33%) and NGOs (12%). The respondents are actively involved in sectors critical

Table 1 Demographic background of respondent

Demographic variables	Groupings	Number of respondents	Percentage of respondent (%)	Total No. respondents
Gender	Male	160	53	300
	Female	140	47	300
Ages	18–24	45	15	300
	25–34	105	35	300
	35–44	75	25	300
	45- 54	45	15	300
	55 +	30	10	300
Marital status	Single	50	17	300
	Married	210	70	300
	Divorced	33	11	300
	Undisclosed	30	10	300
Educational background	No basic Edu	10	3	300
	Basic Edu	45	15	300
	Secondary Edu	95	32	300
	Bachelor degree	120	40	300
	Postgraduate	30	10	300
Geographical location	Rural	120	40	300
	Urban	150	50	300
	Undisclosed	30	10	300
Employment status	Public sector	125	42	300
	Private sector	100	33	300
	NGOs	35	12	300
	Local service provider	30	10	300
	Undisclosed	10	3	300
Sector of employment	Water sector	122	41	300
	Agriculture	43	14	300
	Hospitality	34	11	300
	Municipality	96	32	300
	Undisclosed	5	2	300
Income bracket	Lower Income (< $300)	77	26	300
	Middle income ($300–$1000)	75	25	300
	Upper middle ($1000–$3000)	60	20	300
	Undisclosed	88	29	300

Source: Field survey

to climate adaptation, particularly the water sector (41%) and municipalities (32%), indicating the survey's relevance to professionals engaged in environmental management.

The monitoring and evaluation in the water sector: the strengths and weaknesses of the current framework in South Africa

This paper explores the strengths and weaknesses of the current framework regulating water monitoring and evaluation practices in South Africa. This was done using the Department of Water and Sanitation's frameworks and extensive engagement with water sector experts. The interpretation of Fig. 5, revealed that South Africa's water monitoring and evaluation processes integrate polycentric decentralised management principles derived from SES and ACF at national, provincial, and local levels.

National level: policy formulation and oversight

Nationally, the SES framework ensures that water policies balance ecological sustainability and socio-economic needs through scientific assessments and coordinated policy-making. The ACF principles ensure that the national water policies are influenced by competing advocacy coalitions, including environmental groups and industry stakeholders, who shape legislation

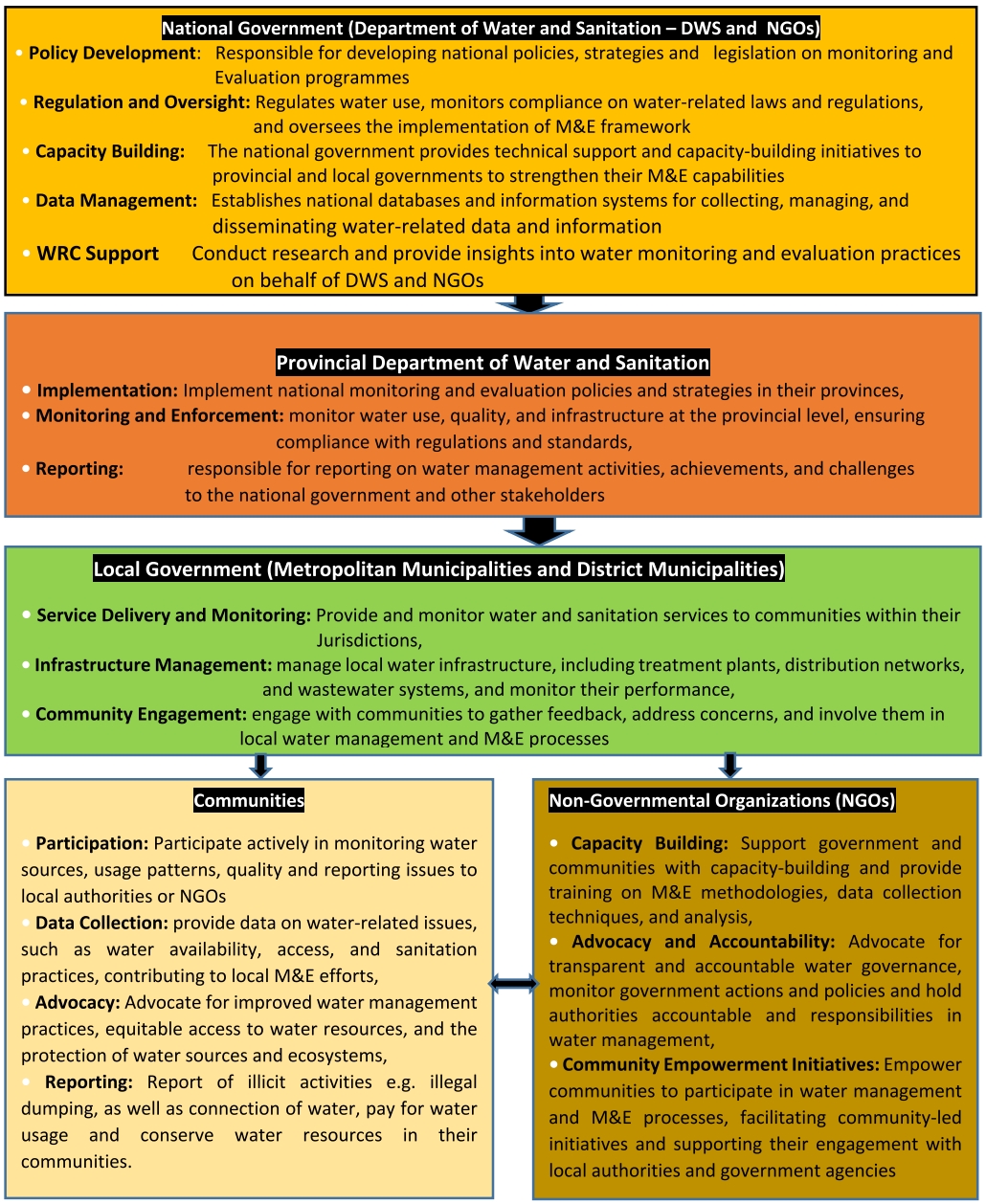

Fig. 5 Monitoring and evaluation framework in South Africa's water sector. Source: Department of Water and Sanitation, 2008

through lobbying and media engagement. NGOs like WaterCAN, Mvula Trust, the Association for Water and Rural Development (AWARD), the Wildlife and Environment Society of South Africa (WESSA) and other research institutions enhance transparency and public participation via citizen science initiatives.

Provincial level: adaptive management

In the provincial level, the provincial government (Provincial DWS) integrate the SES in the adaptive management, using real-time data and cross-sector collaboration to mitigate climate risks. The ACF philosophies highlight the role of advocacy coalitions in shaping industrial water regulations, while grassroots reports drive policy adjustments. NGOs such as Earthlife Africa and Federation for Sustainable Environment (FSE) use litigation other strategies to challenge pollution of water bodies and other environmental issues while community monitoring groups provide accountability and capacity-building for public awareness.

Local level: service delivery & community engagement

At the municipal level, SES values guarantee participatory governance, enhance resilience through conservation strategies and early warning systems. The ACF ideologies warrant grassroots advocacy drives policy reforms, decentralising water management. Water watchdog committees, NGO partnerships, and public education campaigns contribute to enhanced accountability and adaptive capacity. Summarily, an integrated approach leverages SES and ACF to enhances South Africa's water monitoring and evaluation processes. SES fosters adaptive, evidence-based management, while ACF underscores advocacy-driven policy change. NGOs and grassroots organisations bridge management gaps, reinforcing accountability and participatory decision-making for resilient water management Fig. 5 reflects the monitoring and Evaluation framework.

Some of common views shared by respondents suggest that while the framework offers valuable insights and guidance in monitoring and evaluating water resources in the country, their applications is often fraught with challenges due to the inherent complexity of the frameworks, as well as external factors such as policy constraints, resource limitations, and capacity gaps.

Institutional and capacity challenges of monitoring and evaluation in the water sector

This paper explores institutional and capacity constraints to water monitoring and evaluation in South Africa. Participants were asked to mention constraints and the severity of the constraints on monitoring and evaluation processes in South Africa's water sector. Table 2 and Fig. 6 reflects the participant's responses.

The majority of the 45 responses obtained, translating to 15%, mentioned lack of quality data and information as the main obstacle to effective monitoring and evaluation in the country's water sector; this was followed by weak policy and regulatory framework and a lack of meaningful stakeholders' participation. These constraints were mentioned by 43 (14%) and 41 (13.5%), respectively. A lack of political will, cumbersome bureaucratic practices, and inadequate funding were also mentioned by 38 and 35 of the respondents. Based on these outcomes, respondents were asked to rate the level of the constraints under three main variables: "Low levels impacts, High levels and Very High levels of impacts". Using the Likert scale and Ordinal level of measurement, we computed this formula to categorise the responses: Using the formula, answers obtained were classified under Not an obstacle, Less obstacle, Low levels of impact $= 0 \leq x \leq 80$; High levels of impacts $= 80 \leq x \leq 150 =$ and Very high levels of impacts $= 150 \leq x \leq 300$. If the value falls between 0 and 80 (inclusive), it is categorised as "Low levels of impact. "If the value falls between 80 and 150 (inclusive), it is classified as "High levels of impact." If the value falls between 150 and 300 (inclusive), it is labelled as "Very high levels of impacts.

The responses obtained, as demonstrated in Table 2, suggest that all the eight obstacles measured have been categorised as either high or very high impacts. This implies that these constraints have either high or very high hindrances on the overall performance of monitoring and evaluation processes in South Africa's water sector.

Table 2 The levels of impacts of the constraints on water monitoring and evaluation

Types/Nature of Constraints	Level of Significance Based on Respondents Perspectives						Total No. of Respondents	Total Per.%
	Low Levels Impacts	100%	High Level of Impacts	100%	Very Levels of Impacts	100%		
Lack of Quality Data and Information	20	7%	197	66%	183	44%	300	100%
Lack of Meaningful Stakeholders Participation	62	21%	102	34%	136	45%	300	100%
Inadequate Technological Infrastructure	75	25%	110	37%	115	38%	300	100%
Lack of Political Will and Beraucratic Practices	33	11%	98	33%	169	56%	300	100%
Inadequate Funding and Resources	17	6%	87	29%	196	65%	300	100%
Weak Policies and Regulatory Framework	90	30%	141	47%	69	23%	300	100%
Poor Institutional Coordination and Collaboration	23	8%	88	29%	189	63%	300	100%
Lack of Human Capacity and Knowledge	76	25%	186	63%	38	13%	300	100%

Source: Field survey by the Research Team

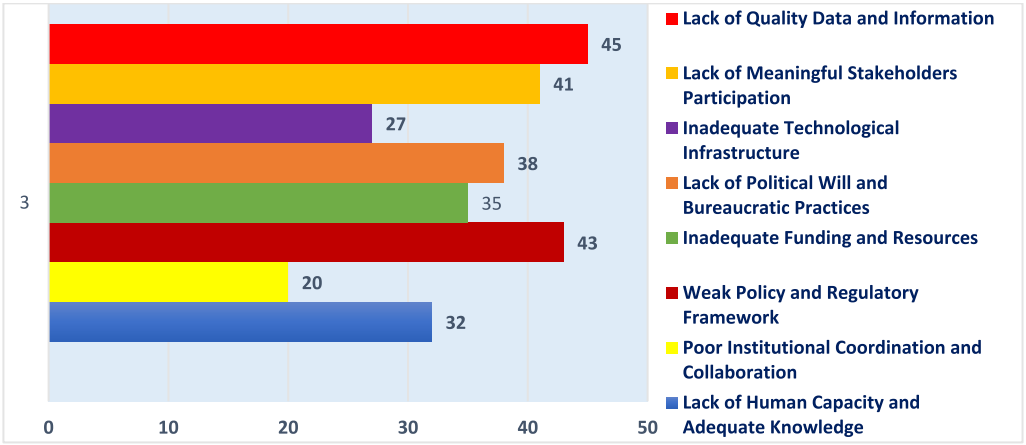

Fig. 6 Barriers to monitoring and evaluation in the South African water sector. Source: Field survey

Other common challenges emanated from the interviews include outdated and inadequate technologies that impede data collection, analysis and dissemination efforts. Unpredictable and out-of-date legal and regulatory frameworks create barriers to effective monitoring and evaluation.

Enhancing monitoring and evaluation processes through alternative strategies

Considering the challenges above, this paper explores strategies for enhancing monitoring and evaluation processes in the South African water sector. Respondents were asked to specify what strategies are required to improve monitoring and evaluation activities and which of these categories, short, medium and long-term solutions, they consider their solutions to fall under. Figure 7 depict the outcomes of respondents.

Responses obtained show that the majority of the respondents 55 translating to 18% are of the view that capacity-building programmes should be prioritised to improve monitoring and evaluation programmes in the water sector; this is followed by 44 (15%) that mentioned the utilisation of sensing technologies; 33,32 and 31 of the respondents cited promotion of private-partnerships, data sharing platforms, promotion of public awareness campaigns and integration of indigenous accordingly as alternative and innovative strategies of improving monitoring and evaluation. Figure 8 reflects the views of respondents on the categorisation of the strategies under short to long-term solutions.

The responses obtained from respondents placed public awareness campaigns, strengthening regulatory frameworks and encouraging data and information sharing platforms as short-term and immediate solutions

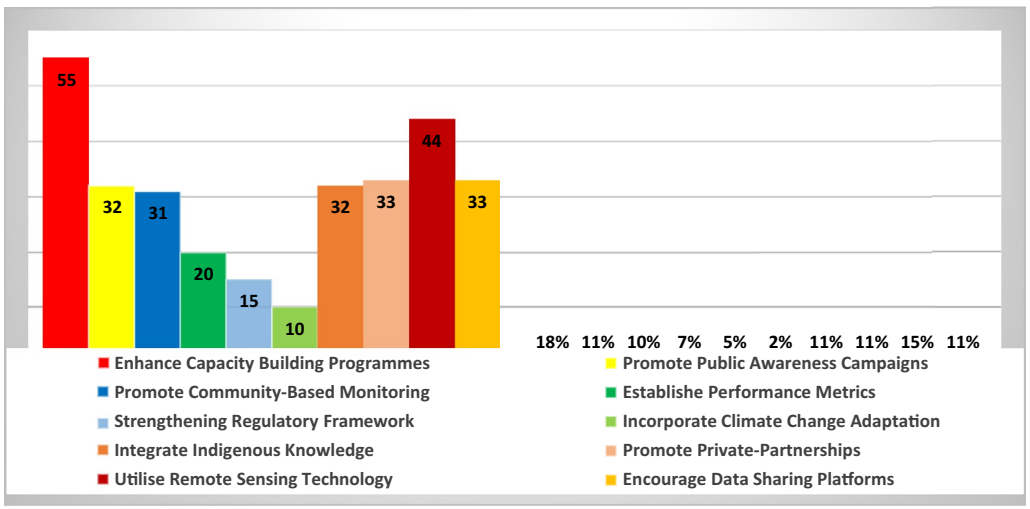

Fig. 7 Perspectives of enhancing monitoring and evaluation processes in South Africa: Source: Field survey by the Research Team

Fig. 8 Strategies for enhancing monitoring and evaluation processes in South Africa. Source: Field survey by Research Team

to enhance monitoring and evaluation processes while capacity building, utilisation of remote sensing and technology and establishment of performance metrics were considered as medium-term strategies, respondents positioned community-based monitoring, integration of indigenous knowledge, incorporation of climate change adaptation and the promotion of public–private partnership as long-term strategies of improving water monitoring and evaluation practices in South Africa. Other common views that emanated from the interviews suggest that enhancing water monitoring and evaluation can be achieved through public education that entails raising awareness of the public, active citizenship in water management and governance and promoting behavioural change for sustainable water management, promoting transparency and accountability in all levels of water management.

Discussions

The discussion of this paper was structured and sequenced to establish a holistic understanding of water monitoring and evaluation of South Africa's water sector under three main objectives, which include the strengths and weaknesses of the current framework of monitoring and evaluation processes, the institutional and capacity constraints and the alternative strategies of enhancing water monitoring in South Africa.

Strengths and weaknesses of the current framework for monitoring and evaluating Africa water resources in South Africa

The underlying views of Fig. 5, reveals that the South Africa's water monitoring and evaluation processes are structured within systematic, multi-layered management frameworks, aligning well with SES and ACF guidelines. The interpretation of Fig. 5, indicate that at the national level, the DWS functions as the central authority, formulating policies, setting regulatory standards, and overseeing national water monitoring and evaluation strategies. The Green Drop standards of water management which include: potable water quality, effective treatment processes, regular testing, reliable infrastructure, operational capacity, and transparent reporting, wastewater treatment standards as well as Blue Drop requirement of mandated effluent quality compliance with the National Water Act, efficient treatment processes, sampling of wastewater quality, reliable system maintenance and adequate resource management to ensure safe discharge and environmental protection are key regulatory metrics and benchmark used to evaluate compliance across the country. The underlying views of Fig. 5 suggests that the national monitoring framework relies on data collection, reporting mechanisms, and periodic audits to track the effectiveness of water management and service delivery at all levels. These components are entrenched in the SES and ACF guidelines.

At the provincial level, Fig. 5 uncovered that provincial departments play a critical oversight and support role, particularly in monitoring municipal performance and evaluating compliance with national water policies. The underlying findings from Fig. 5, suggests that when municipalities fail to meet water service obligations, provincial governments use the monitoring and evaluation reports to identify inefficiencies and recommend corrective actions. The provincial institutions also play a critical role in assessing the impact of climate change on water resources and integrating adaptive strategies into water management. These requirements are deep rooted in the SES and ACF guidelines. At the local level, municipalities are identified as the primary service providers, responsible for water distribution, infrastructure maintenance, and ensuring access to potable water and sanitation services. The important message of Fig. 5 revealed that municipalities are required to implement monitoring and evaluation systems to track water supply, sanitation coverage, and infrastructure conditions, ensuring that service delivery remains effective, equitable, and sustainable. The remarkable finding is that this layered governance structure reflects Ostrom's concept of polycentric governance, where multiple decision-making centres operate independently yet collaboratively to ensure sustainable water resource management. Additionally, the presence of advocacy coalitions, including Water Boards, civil society organisations, and industry stakeholders, actively engage in the monitoring and evaluation of water policies, reinforcing ACF principles of coalition-driven policy evolution. These coalitions set the foundation to influence policy adjustments based on monitoring and evaluation findings, ensuring continuous learning and adaptation

in water governance. Summarily, the findings of Fig. 5 as well our engagements conclude that South Africa's water management system is structured to promote decentralised management, stakeholder participation, and evidence-based policy-making through continuous monitoring and evaluation.

However, the underlying views of many experts engaged revealed several concerns and weaknesses in the application of the SES and ACF frameworks in the monitoring and evaluating South Africa's water resources to achieved the desired goals. These range from complexity, rigid procedures and bureaucratic procedures attached to these frameworks. Majority of the experts suggest that these frameworks are riddle with weaknesses which include lack of monitoring mechanisms, challenges with data integration and pretence of equal stakeholder participation and decision-making, despite power imbalances and high levels of inequalities in the country. These views are shared by Hutete et al. (2022) that South Africa is the most unequal country in the world, as evidenced by its high Gini coefficient (a measure of income inequality) and a stark contrast between the wealthy and the impoverished. This inequality is not confined to economic and social realms but transcends into key public services, including water management and decision-making in monitoring and evaluation processes (Todes et al. 2017). The unequal distribution of water resources, inadequate access, and unequal participation in management processes are all reflections of South Africa's broader societal inequities. Another remarkable finding from our engagements revealed that the SES and ACF guidelines focus on long-term goals with less attention on urgent water crises facing majority of the population. Furthermore, the frameworks primarily focus on analysing policy coalitions rather than scientific monitoring, overlooking corruption and political interference and often places emphasis on elite groups rather than grassroots involvement, a sharp contrast to the principles of the ACF and SES. Funke et al. (2020) shared similar sentiments stating that the frameworks are extremely complex and riddled with regulatory structures that are complicated to understand and implement. Additionally, it was uncovered that the frameworks lack applicability within the local context due to cultural dissonance, historical inequalities, geographical diversity, alienation of traditional knowledge, neglect of economic realities, mismatches with legal and governance structures, oversight of environmental factors and inadequate community participation. These interlinkages and interconnected factors have hindered the effective and pragmatic execution of the frameworks to meet the desired outcomes.

Institutional and capacity constraints to monitoring and evaluation in South Africa water sector

In terms of institutional and capacity constraints, the outcomes of Table 2 and Fig. 6 suggest that several interwoven constraints hinder the implementation of the water monitoring and evaluation framework in South Africa. The outcomes identified significant challenges such as a lack of quality data and information, a dearth of meaningful public participation, a weak regulatory framework, and a lack of political will, and inadequate funding and resources as fundamental obstacles to effective monitoring and evaluation processes in the water sector. These findings underscore the views of Makaya et al. (2020), Kruger et al. (2022) and Mthethwa and Jili (2016) that the monitoring and evaluation processes in South Africa from the national to the local spheres are hindered by significant constraints, which include institutional and capacity constraints, inadequate human capital and expertise, technological and innovative barriers, funding limitations, data and information debts and policy and regulatory uncertainties. The underlying results of Table 2 and Fig. 6 suggest that these constraints mutually retard the effective collection, analysis and interpretation of water-related data, which undermines decision-making and overall management of water resources in the country. Evidence of these is witnessed in the recently release Green and Blue Drop reports of rapid decline of water quality across the country, particularly in the rural communities, inefficient allocation and distribution of water resources, leakages and unaccounted water losses, delayed response to water crisis events, lack of accountability and corruption, constant breakdown and decay of water infrastructure projects, regular water interruptions and massive pollution of the country's rivers, lakes and dams from mining, agriculture and domestic and municipality wastes. Furthermore, the ineffectiveness of the monitoring systems is demonstrated in the countless protests, litigation, and advocacy efforts, all signalling the lack of confidence in the effectiveness of the monitoring and evaluation processes.

Strategies to enhance monitoring and evaluation programs in South Africa's water sector

This paper explored strategies for enhancing monitoring and evaluation using SES and ACF in the country's water management as shown in Figs. 7 and 8. The findings of Fig. 7 suggest that to improve monitoring and evaluation processes, prominence must be given to capacity programmes in the form of training, upgrading and re-skilling of employees, utilisation of remote sensing and innovative technologies, promoting

data and information sharing, bolstering public–private partnerships and promoting community-based monitoring of water resources. The underlying outcomes from Fig. 7 suggest that only well-coordinated integration of different strategies ranging from improved data sharing, competent labour force, substantial funding, active involvement of all stakeholders and integration of innovative technologies will enhance monitoring and evaluation programmes in South Africa's water, taking into consideration the complexities and interconnectedness of challenges in the country's water issues. Similar sentiments were shared by Rosenberg et al. (2020), Makanda et al. (2022) and Adom and Simatele (2021) that implementing strategies in isolation and in silos will have narrow and minimal results on monitoring and evaluation processes in the water sector. We established that incorporating multiple strategies simultaneously will achieve maximum outcomes in the monitoring processes. Based on our exploration, capacity-building programmes must be complemented by data collection and information sharing, and technologies will improve accuracy in analysis, while public participation and involvement will increase legitimacy and acceptance. Similarly, we noticed that coalescing these strategies and leveraging synergies, monitoring, and evaluation programmes will become more robust, adaptive, and impactful in realising water resource management goals.

In terms of Fig. 8, the findings suggest that enhancing the performance of the SES and ACF frameworks in water management must be spread across short, medium and long-term timeframes. The results revealed that public awareness campaigns, strengthening of a regulatory framework, and encouraging data and information sharing were deemed as short and immediate strategies required to enhance water monitoring and evaluation processes in water management and governance; these were followed by medium-term strategies that include capacity building, utilisation of remote sensing and technologies and establishment performance metrics while long term-term strategies must encompass community-based monitoring, incorporation of climate change adaptation to monitoring framework, public–private partnerships and integration of indigenous knowledge in water governance. The underpinning evidence from Fig. 8 suggests that enhancing the performance of monitoring and evaluation framework on short, medium, and long-term phases is vital in assessing immediate effects, tracking the progress, guaranteeing sustainability, facilitating learning and adaptation, building resilience to climate change, effective resource allocation, and foster accountability and transparency in the entire water sector. Similar views were shared by Mahlala (2024) that enforcing the monitoring and evaluation of South Africa's water management on the basis of short, medium and long-term timeframes will bolster accountability and transparency, improve reporting on progress and outcomes, bolster commitment to the vision and the goals of government, allow for scrutiny by stakeholders, heighten trust and confidence in framework and governance efforts.

Conclusion and recommendation

South Africa has enacted a comprehensive framework to monitor and evaluate its water resources sustainably to achieve water security for the entire population. However, implementing and enforcing this framework to achieve these goals have failed to materialise due to interconnected and multifaceted challenges that include complexities in the governance layout, complicated bureaucratic set-up, over-ambitious monitoring systems, lack of human capacity, inadequate funding, lack of data and information to make informed decisions and lack of meaningful public participation, and involvement in water management and governance in the country. Based on the findings of this study, there is the need for a broader, more inclusive approach to water management, moving beyond traditional roles assigned to users, stakeholders, policymakers, and regulators. Instead, the study recommends fostering cooperation, partnership, and stewardship to enhance water resource management. Achieving sustainable and inclusive monitoring and evaluation processes in South Africa will range from short to long-term approaches. In the short term, it is essential to strengthen stakeholder participation and transparency through community consultations, establish capacity-building initiatives to train local leaders and NGOs in sustainable water management practices, and initiate legal reforms to decentralise water management to local authorities. Additionally, enhancing multi-level monitoring systems for water quality and usage should be prioritised, along with formalising community-based water management systems and implementing conflict resolution mechanisms. In the medium term, the focus should shift towards scaling up the use of smart water management technologies, such as AI-driven analytics, to optimise resource allocation and resilience. Legal frameworks that support decentralised water management should be institutionalised, while conflict resolution mechanisms and continuous community engagement should be embedded into decision-making processes. While in the long term, full integration of smart technologies like AI and blockchain should be expanded to ensure more efficient and equitable water distribution. Ongoing adaptation to climate change through resilient water management

strategies should be prioritised, alongside strengthening the legal and institutional structures that guarantee inclusive participation and effective conflict resolution in water governance. These solutions will promote a holistic, coordinated, and adaptive water management system to address both current and future challenges.

Future research

While this study covers water monitoring and evaluation processes in South Africa extensively, future research should explore the integration of AI and smart technologies to enhance data accuracy, real-time decision-making, and predictive analytics. Investigating the role of AI-driven models, and machine learning algorithms could provide insights into optimizing monitoring and evaluation processes for improved sustainability and governance.

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Declaration statement
All authors have read, understood, and have complied as applicable with the statement on Ethical Responsibilities of Authors as found in the Instructions for Authors.

Author contributions
RKA: Collected data, analysed the data and wrote the main manuscript. MDS: Supervised and provided funding for the writing of manuscript.

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Data availability statement
Data supporting the findings of this study are available upon request from the corresponding author. The data are not publicly available because of privacy and ethical restrictions.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with ethical guidance and regulations of the University of Witwatersrand. Informed consent was obtained from all participants involved in the study, their confidentiality and anonymity were strictly maintained. All participants in this study provided informed consent to participate in the research. Prior to data collection, participants were fully informed about the purpose, procedures, potential risk and benefits of the study. Participation was entirely voluntary and participants had the right to withdraw at any time without any consequences. Confidentiality and anonymity of participants were ensured throughout the study in compliance with ethical research standard of University of Witwatersrand.

Consent for publication
I Richard Kwame Adom, the corresponding author on behalf of my co-author hereby confirm that we grant Journal Environmental Science and Pollution Research the exclusive right to publish this manuscript titled: The Environmental and Social Implications of Electronic Waste in Ghana, should it be accepted. We declare that the work has not been published elsewhere and is not under consideration for publication in any other journal.

Competing interests
The authors declare no competing interests.

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