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CHALLENGES IN THE REGULATION OF WATER DEMAND PLANNING IN SOUTH AFRICA

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Abstract. South Africa is confronted with the challenges of dual governance systems, ineffective implementation of water legislation, and conflicts arising from differing governance approaches, all of which impede the effective management of integrated water resources. This article aims to understand the significant challenges in regulating water demand planning in South Africa. The research methodology employed in this study consists of a rapid review complemented by open-ended interviews, facilitating data triangulation that enables a comparative analysis between insights gathered from interview participants and the results obtained from the rapid review. The rapid review involved a comprehensive examination of fifty-five articles, of which twelve met the established inclusion criteria for the study. Additionally, five managers from the Vhembe district municipality were interviewed. The key dimensions investigated include an evaluation of study quality, a narrative synthesis of study outcomes, an exploration of the barriers and facilitators associated with implementing water demand planning regulations, and interventions designed to support such regulations. The findings underscore significant challenges in regulating water demand planning in South Africa, including project delays, budget overruns, substandard quality of work, mismanagement of funds, and insufficient service delivery. Recommendations emphasize the necessity of implementing water demand forecasting, which serves as a fundamental component of all planning efforts within the water services sector and aims to project the future water requirements of the designated planning area.

Keywords: water demand management; South Africa; water regulation; service delivery; governance

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1. Introduction

The regulation of water demand planning in South Africa (SA) encounters several challenges, including unsustainable water consumption patterns, insufficient infrastructure, accelerated urbanization, corruption, and a deficiency in stakeholder engagement (Adom & Simatele, 2024). SA is currently facing significant challenges related to water scarcity, with an anticipated increase in demand of 17% by the year 2030. Furthermore, it is noteworthy that 37% of urban piped water is lost, underscoring the urgent necessity for effective water management strategies (Feukeu et al., 2022). In 2017, South Africa experienced a notable rise in intermittent water supply, impacting approximately 22 million individuals (Loubser et al., 2021).

The water use license application system in SA is operating ineffectively, which obstructs the achievement of its intended objectives and the fulfilment of relevant constitutional provisions (Moolman et al., 2022). The regulation

of water resources in SA is hindered by issues such as inadequate pricing, suboptimal returns on capital investments, elevated levels of non-revenue water, and a substantial deficit in capital investment (Ruiters & Amadi Echendu, 2022). In SAn urban areas, the average percentage of non-revenue water exceeds 37%, with certain regions experiencing figures as high as 60% (Steyn, 2022a).

The difficulties associated with regulating water demand planning in SA arise from historical disparities, the shift away from riparian rights, and the necessity to integrate social norms to ensure equitable distribution of water resources (Madigele, 2018). SA is characterized by the presence of dual governance systems, inadequate implementation of water legislation, and conflicts arising from differing governance approaches, all of which impede the effective management of integrated water resources (Stuart-Hill et al., 2020). The regulatory framework pertaining to greywater management in informal settlements in SA encounters several obstacles, including inconsistencies, ambiguity, and insufficient enforcement mechanisms (Vala & Malazaa, 2024).

SAn municipalities lack defined responsibilities for collecting essential water service data, resulting in challenges related to the quality, integrity, and timeliness of such data (Steyn, 2022b). In SA, the water infrastructure sector is experiencing significant challenges, including project delays, budget overruns, substandard quality of work, mismanagement of funds, and insufficient service delivery (Aiyetan & Das, 2021). The management of water resources in SA is characterized by inefficiencies stemming from institutional ambiguities, challenges related to policy adherence, and a decline in water quality (Adom & Simatele, 2024).

The present study's authors initiated a participatory research project in collaboration with managers from the VDM between March 2021 and November 2021. The initial phase of the current study involves a systematic search and rapid review of existing academic literature. This will be succeeded by original research, including interviews with VDM managers. Collectively, these two data sources will guide the design and implementation of the study.

2. Method

The study employs a qualitative case study methodology. The case setting is the Vhembe municipality in Limpopo, SA. Data were gathered from participants through open-ended interviews. A non-probability sampling approach was utilized for the interviews, specifically through purposive sampling. This method involves selecting samples based on predetermined criteria pertinent to the research objectives. Purposive sampling, also referred to as purposeful or judgment sampling, operates on the principle that identifying the most relevant cases for the study yields the most valuable data, thereby ensuring that the research findings are directly influenced by the selected cases (Mweshi & Sakyi, 2020).

Purposive sampling was chosen as a methodological approach to identify a specific population and investigate their characteristics, perceptions, and intentions. Deviant case sampling, a subset of purposive sampling, enables researchers to focus on individuals representing the lower or less favourable end of a given scale, thereby facilitating an understanding of their experiences. In this context, the researcher seeks to derive insights from participants perceived as underperforming or experiencing failure (Nyimbili & Nyimbili, 2024). The study employs open-ended interviews with questions designed to elicit detailed responses, promoting a discovery-oriented methodology. In-depth interviews allow the interviewer to maintain an elevated level of concentration and internalization, which aids in establishing rapport and improving the relationship between the participant and the researcher (Roller, 2020).

The interviews were conducted over an extended period, specifically from March 2021 to November 2021, enabling the researcher to gather substantial data. This timeframe facilitated the opportunity to pose follow-up questions and clarify any inconsistencies in the participants' responses. Before the interview sessions,

appointments were arranged in advance with the participants. The researcher engaged in interviews with a total of five individuals, with each session lasting between forty minutes and two hours.

The research methodology employs open-ended interviews in conjunction with a rapid review to enable data triangulation, thereby facilitating a comparative analysis between the insights gathered from interview participants and the results obtained from the rapid review. Rapid reviews have been advocated as an effective approach to delivering timely and resource-efficient literature summaries by utilizing techniques that expedite or optimize conventional systematic review processes (Moons et al., 2021). The objectives of this rapid review encompass the provision of prompt evidence to facilitate decision-making processes and the enhancement of evidence-based decision-making in the regulation of water demand planning within the context of SA (Arevalo-Rodriguez et al., 2023).

This rapid review aims to systematically assess the existing body of knowledge regarding regulating water demand planning in SA. This assessment will facilitate the exploration of the following questions:

- What is understood regarding the regulation of water demand planning in SA?
- What approaches have been implemented by institutions that have effectively managed water demand planning regulations in SA?
- What interventions have been tested and identified as effective or ineffective in enhancing the regulation of water demand planning in SA?

2.1. Search strategy and inclusion criteria for the rapid review

A systematic search of academic journal articles was performed in August 2024, focusing on examining abstracts and keywords within various databases. The databases searched were Scopus, GreenFILE, PAIS Index + Archive, Academic Search Ultimate, Business Source Ultimate, ProQuest Central, and Waters & Oceans Worldwide. Search terms were: “South Africa” AND (regulation OR laws OR statutes OR mandates) AND “(water demand planning” OR “water demand management)” AND (government OR “public management” OR “public sector” OR “public administration)”

The database search yielded a total of 419 items (refer to Figure 1). No further items were sourced from alternative methods, such as ancestry searches of reference lists or tracking the citations of authors. A total of fifty-eight duplicates were eliminated from the dataset. The titles, abstracts, and keywords of the remaining 361 articles were subsequently reviewed to assess their potential eligibility. Fifty-five articles passed the inclusion criteria as they ranked highest based on the mention of the greatest number of words or phrases from the search phrases "South Africa" AND (regulation OR laws OR statutes OR mandates) AND "(water demand planning" OR "water demand management)" AND (government OR "public management" OR "public sector" OR "public administration)" in either their title, abstract, and or keywords. No restrictions were imposed regarding the year of publication to encompass all potentially pertinent articles.

The PRISMA 2020 statement offers a revised guideline for the reporting of systematic reviews and meta-analyses, superseding the 2009 statement. It features a 27-item checklist, an elaborated checklist that specifies reporting recommendations for each item, and updated flow diagrams for both original and revised reviews. The statement aims to enhance the transparency and thoroughness of reporting in systematic reviews, which will be advantageous for authors, editors, and users of these reviews (Matthew et al., 2021).

The terminology associated with systematic reviews and meta-analyses has changed significantly over time. The transition from QUOROM to PRISMA reflects an intention to include both systematic reviews and meta-analyses within its scope. A systematic review is characterized by its focus on a well-defined research question. It employs systematic and transparent methodologies to identify, select, and critically evaluate pertinent studies and gather and analyze data from these studies.

The application of statistical methods, known as meta-analysis, may be utilized to synthesize and summarize the findings of the studies included in the review. However, it is not a mandatory component. Meta-analysis denotes explicitly the application of statistical techniques within a systematic review to amalgamate the results of the studies considered (Ahn & Kang, 2018). The preferred items for reporting systematic reviews and meta-analysis (PRISMA) were used.

A total of fifty-five articles underwent a comprehensive full-text review, identifying twelve articles that satisfied the established inclusion criteria. For an article to be considered for this review, it was necessary to fulfil one of the following conditions: (1) it addressed the regulation of water demand planning in SA; (2) it proposed strategies for institutions to enhance their regulation of water demand planning in SA; or (3) it presented interventions aimed at improving the regulation of water demand planning in SA. Ultimately, only twelve articles were found to meet the inclusion criteria.

2.2. Quality Appraisals

The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement and The Joanna Briggs Institute (JBI) are recognized as prominent critical appraisal tools for evaluating the reporting of items in review studies (Borges Migliavaca et al., 2020). Both frameworks exhibited limitations in evaluating the twelve studies under consideration, primarily due to their focus on experimental, quasi-experimental, and systematic research methodologies.

Nevertheless, they contributed to formulating a modified appraisal checklist designed to evaluate the studies' theoretical synthesis and methodological rigour. The quality appraisal checklist consisted of five criteria, each evaluated on a three-point scale: 1 = low, 2 = medium, and 3 = high, resulting in a total score range of 5 to 15.

These criteria pertained to the clarity of the following aspects: definitions of the population; interventions, comparators, or critiques; methodological approaches; considerations of validity, reliability, and theoretical frameworks; and the consistency of results, discussions, and limitations in relation to the stated methodological framework. The overall quality assessment was derived from the mean scores across the five quality appraisal criteria.

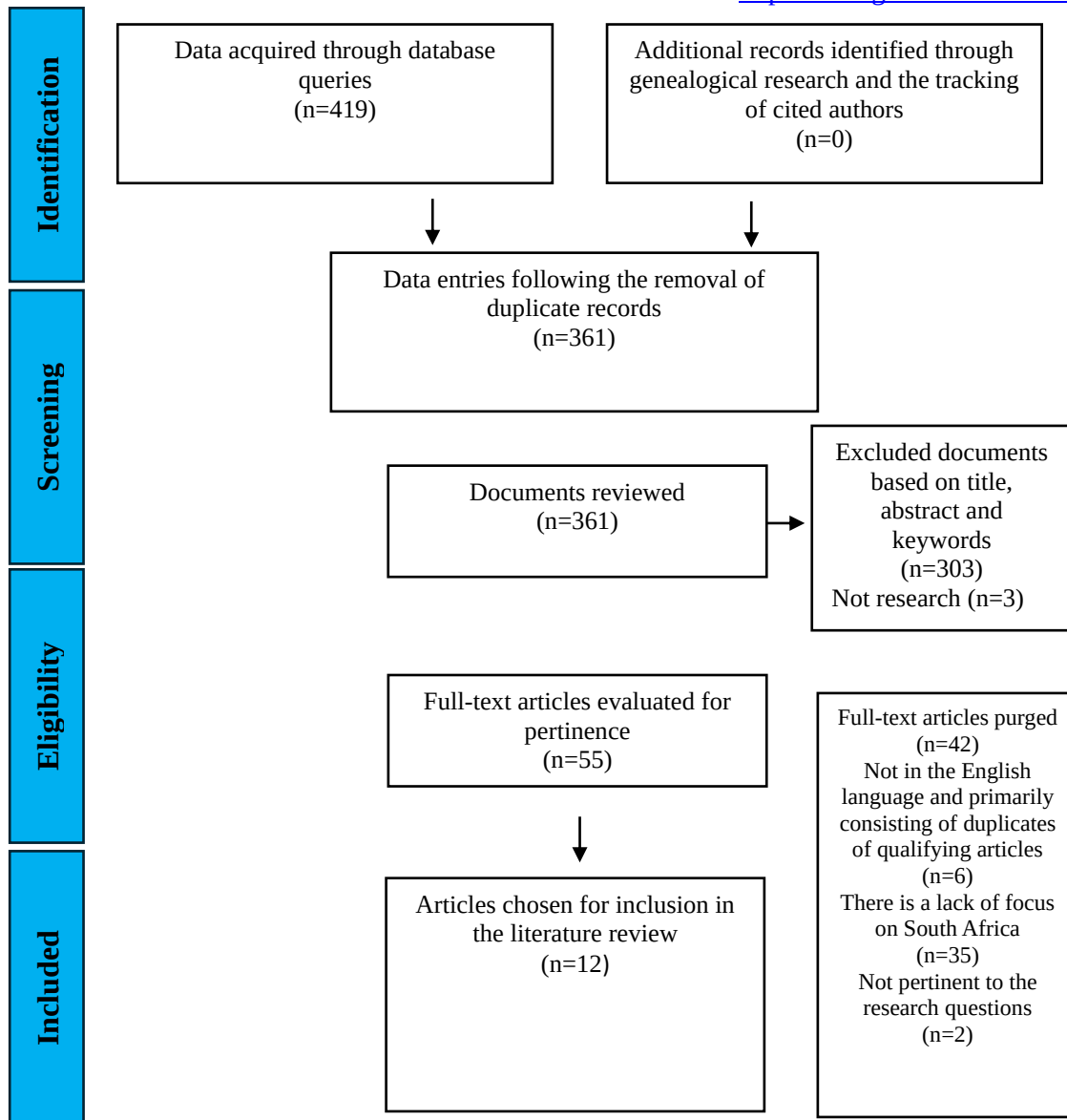


Fig. 1. PRISMA process for reporting rapid reviews

Source: Authors own creation

3. Literature review: results from the rapid review

Data from twelve research studies were systematically extracted and compiled into a summary table (Table 1), delineating the research focus, methodology, and significant findings pertinent to regulating water demand planning in SA. An evaluation of the quality of the studies was conducted (Table 2), which was subsequently followed by a narrative synthesis of the study outcomes. The primary emphasis was placed on identifying the barriers and facilitators associated with implementing regulations for water demand planning, as well as interventions designed to support such regulations. Of the twelve studies evaluated, seven investigated the significance of knowledge pertaining to Water Demand Management (WDM) (Daane, 1998; Mwendera et al., 2003; Colvin & Saayman, 2007; Mathipa & Le Roux, 2009; Wolfe, 2009; Price et al., 2012; Crous et al., 2013; Murwirapachena, 2021).

Wolfe (2009) posits that tacit knowledge is instrumental in influencing WDM practices and their effective execution. Daane (1998) highlights the necessity of comprehending WDM to make well-informed strategic investment choices. Price et al. (2012) point out a significant gap in educational initiatives related to water conservation, advocating for the launch of awareness campaigns to enhance understanding of WDM.

Additionally, Mathipa and Le Roux (2009) reveal that participants in their study demonstrated a deficiency in practical knowledge regarding WDM strategies, thereby emphasizing the critical role of knowledge in promoting effective water conservation practices.

Table 1. Overview of research studies and articles included

Author (Year), Article type	Research Focus	Sample, Research design, analysis	Key findings pertinent to the regulation of water demand planning in SA
(Wolfe, 2009), Academic peer review paper	Examining the implicit knowledge possessed by WDM professionals within municipal contexts	Research Design: A qualitative thematic analysis focusing on the tacit knowledge of WDM practitioners. Sample: Municipal practitioners from Ontario, Canada, and Southern Africa. Analysis: A comparative characterization of both explicit and tacit knowledge related to WDM.	Discussions and practices surrounding WDM are predominantly informed by explicit knowledge. However, the tacit knowledge possessed by practitioners plays a significant role in the implementation and overall success of WDM initiatives.
(Daane, 1998), Dissertation	The implementation of residential water metering in multi-unit high-rise buildings for demand management. The examination of cost recovery strategies within the context of the former Soviet Union (FSU) and Eastern Europe.	The research design encompasses a cost-benefit analysis conducted in Lviv, Ukraine. The sample for this study consists of multi-family residential high-rise buildings in Eastern Europe and the former Soviet Union (FSU) republics.	Utilizing volumetric-based metering in high-rise buildings is an economically efficient strategy for managing demand. Furthermore, the implementation of conservation measures is essential for the effective management of water resources.
(Jiang et al., 2010), Academic peer-review paper	The development of an urban water quota management system in China. Formulation and execution of WDM strategies.	Sample: Urban Water Management Systems in China Research Design: Examination of the effects of water quota management Analysis: Emphasis on water demand, efficiency, and resource distribution.	The management of urban water quotas significantly improves strategies for planning water demand. The implementation of a water quota index system facilitates the effective regulation of water demand. Furthermore, the development of the water quota system has transitioned towards encompassing general industries for enhanced planning purposes
(Jonker, 2012), Dissertation	Water management strategies for electricity generation in SA. Dry cooling systems and wet cooling systems utilization in power plants	Protocols exist that delineate the requirements for water metering in power generation facilities. Conducting an economic analysis of cooling systems is essential in the design of power plants. The primary contributor to Eskom's electricity expenses is the generation function.	Water demand planning is essential for the sustainable generation of power. Strategic action plans have been developed to guarantee sufficient water resources for power generation activities.
(Price et al., 2012), Academic peer-review paper	Water conservation and demand management strategies within the Nelson Mandela Bay Municipality. Strategies for the reduction of water loss and the enhancement of sustainable water service delivery	Research Design: Implementation of Water Loss Management Services in Nelson Mandela Bay. Sample: Water supply zones, water metering systems, and community standpipe facilities. Analysis: Calibration of the network, assessment of pressure measurements, identification of leaks, and analysis of flow dynamics.	Emphasizes the importance of minimizing unbilled authorized consumption and mitigating apparent losses. Effective pressure management is crucial for the sustainability of service delivery.
(Mathipa & Le Roux, 2009), Academic peer- review paper	Training requirements for community-based water management in SA Educational initiatives aimed at promoting WDM and conservation practices in rural communities.	The research design encompassed the collection of data through interviews. The analysis involved the identification of water usage patterns and the development of educational programs. The sample comprised residents from the villages of Mangabane and Makgemeng.	Effective WDM necessitates the implementation of organized educational and training initiatives. Community-oriented programs play a vital role in promoting sustainable water conservation practices. Furthermore, public awareness campaigns are essential for fostering participation in water conservation efforts.

(Crous et al., 2013), Academic peer-review paper	The water demand patterns associated with community ablution facilities in SA. This study examines water consumption associated with laundry activities, toilet flushing, and periods of peak demand. It further analyses water requirements for communal facilities to support hydraulic modelling efforts	The study involved a sample of 233 community ablution blocks (CABs) located within 105 informal settlements, alongside a survey of 1,021 households. The research design incorporated end-use water monitoring, using data loggers, and applying the Weibull distribution to assess peak flow rates. Data analysis was conducted using Microsoft Excel, where missing data was addressed, and peak factors were calculated.	The water consumption for laundry purposes accounts for 60% of total usage, while toilet flushing constitutes 16%. Additionally, the peak demand factors for ablution facilities surpass the established municipal standards. Furthermore, the construction timeline for the CAB project has exceeded the initially allocated budgeted duration, thereby affecting overall project expenditures
(Pienaar et al., 2017), Academic peer-review paper	The implications of water resources associated with the transition to a green economy in the Western Cape Province are examined. A system dynamics model is utilized to assess strategic interventions aimed at facilitating this transition. Additionally, the study identifies various factors that impact both the transition to a green economy and the management of water resources within the province	Research Design: A system dynamics model aimed at facilitating the transition to a green economy. Sample: Stakeholders within the water sector of the Western Cape Province. Analysis: Examination of water demand, costs associated with interventions, and the implications of system dynamics.	The planning of water demand significantly influences the transition towards a green economy in the Western Cape region. The Water Stress Index serves as a tool for assessing risk and directing the implementation of necessary interventions. Additionally, various scenarios have been formulated to effectively manage water demand and promote sustainability.
(Mwendera et al., 2003), Academic peer-review paper	Constraints in WDM within Southern Africa. Approaches to address challenges in the implementation of water sector initiatives	Sample: The study was conducted across six countries and identified various constraints and strategies Research design: An evaluation of the limitations associated with WDM, along with viable solutions and instances of successful implementation Analysis: The recommendations emphasize the necessity of adapting to the evolving socio-economic landscape to facilitate the implementation of WDM.	The implementation of WDM is impeded by insufficient resources, which results in a predominant focus on supply-side solutions. It is essential for stakeholders to be informed about the advantages of WDM to facilitate its effective execution. Furthermore, regulatory bodies should designate managers to address issues of non-compliance and to oversee cost recovery processes
(Colvin & Saayman, 2007), Academic peer-review paper	Groundwater governance in Cape Town, SA The use of the Trialogue model for the management of groundwater Social, policy, and technological aspects in public sectors	Research design: Interviews, literature review, household surveys Sample: Public, hydrogeologists, major stakeholders in groundwater governance Analysis: Evaluating governance mechanisms in Cape Town, alongside the scientific comprehension of groundwater resources	The implementation of WDM strategies resulted in a rise in the utilization of private boreholes. Land ownership reform initiatives have also been designed to promote equitable access to water resources. Furthermore, the level of societal trust in governmental institutions significantly affects patterns of resource utilization
(Ngcobo et al., 2023), Academic peer-review paper	The influence of demographic factors on water consumption patterns in Durban. The implementation of water-efficient technologies within residential settings in Durban	Sample: A cohort of 300 heads of households from various regions within Durban. Research Design: A descriptive methodology employed to examine patterns of water consumption behaviour. Analysis: Utilization of probit regression models to identify factors influencing water-efficient behaviours	Income consistently affects the adoption of water-efficient practices. The level of education plays a significant role in the implementation of water-saving technologies. Additionally, the size of a household serves as a determining factor in the installation of water-efficient technologies.
(Murwirapachen, 2021), Academic peer-review paper	The study examines household water consumption patterns and the adoption of water-efficient appliances in Johannesburg. It also explores the influence of demographic variables on water usage behaviour and the adoption of water-saving appliances.	Sample: A total of 889 households in Johannesburg were surveyed, representing a diverse range of demographic characteristics. Research design: Probit regression models are utilized in the analysis of survey data pertaining to water consumption Analysis: Descriptive statistics, biographical data, water-efficient appliance adoption patterns	Older, male, and lower-income groups practice efficient water-use behaviour. Biographical variables typically do not significantly impact the adoption of water-efficient appliances. Therefore, it is advisable for policymakers to focus their efforts on younger individuals, women, and households with higher income levels

Source: Authors' creation

Table 2. Evaluations of the quality of the reviewed research

Author (Year, article type)	Clarity of population and/or data set (i)	Clarity of intervention and/or comparator (ii)	Technical rigour and/or theoretical approach (iii)	Validity, reliability and objectivity (iv)	Methodological clarity of results/discussion (v)	Overall study quality (vi)
(Wolfe, 2009), Academic peer review paper	medium	high	medium	high	high	high
(Daane, 1998), Dissertation	medium	high	medium	high	high	high
(Jiang et al., 2010), academic peer-review paper	low	high	medium	high	high	high
(Jonker, 2012), Dissertation	low	high	medium	high	high	high
(Price et al., 2012), journal	low	high	medium	high	high	high
(Mathipa & Le Roux, 2009), academic peer-review paper	medium	high	medium	high	high	high
(Crous et al., 2013), academic peer-review paper	medium	high	medium	high	high	high
(Pienaar et al., 2017), academic peer-review paper	low	high	high	high	high	high
(Mwendera et al., 2003), academic peer-review paper	medium	high	low	high	high	high
(Colvin & Saayman, 2007), academic peer-review paper	high	high	medium	high	high	high
(Ngcobo et al., 2023), academic peer-review paper	high	high	high	high	high	high
(Murwirapachena, 2021), academic peer-review paper	high	high	medium	high	high	high

Source: Authors' creation

3.1. Summary of the Studies Incorporated

The literature review used in this study encompasses twelve research studies that collectively examine water demand planning in SA, reflecting the complex and diverse nature of water management strategies. Wolfe (2009) emphasizes the significance of tacit knowledge among practitioners of WDM. Price et al. (2012) investigate water conservation initiatives within the Nelson Mandela Bay Municipality. Jonker (2012) explores the intersection of water management and power generation, crucial for promoting sustainable water use in industrial settings. Additionally, Pienaar et al. (2017) analyze the ramifications of transitioning to a green economy, while Mwendera et al. (2003) identify the challenges encountered in implementing WDM throughout southern Africa. These studies highlight the critical roles of regulatory frameworks, stakeholder engagement, and effective WDM strategies in achieving sustainable management of water resources in SA.

3.2. Quality of Studies

The research quality across the examined studies was consistent, with all twelve studies classified as high quality. Nevertheless, when considering the specific sub-categories employed to assess the overall quality, certain studies performed less favourably in particular evaluation criteria. For instance, regarding the population and/or data set, Jiang et al. (2010) received a low score due to insufficient clarity concerning the study population, as it predominantly addressed the entirety of China. An additional illustration pertains to the technical rigour and theoretical framework employed in research. For instance, Mwendera et al. (2003) received a low score as the study did not explicitly reference or implement any technical rigour within the research paper.

3.3. The regulation of water demand planning in SA

Numerous studies have engaged in discussions concerning regulating water demand planning in SA. A prevalent theme across these studies is the necessity of integrating technical solutions with institutional frameworks and stakeholder involvement to achieve sustainable water management. The significance of knowledge and expertise in implementing WDM is frequently underscored, as noted by Wolfe (2009), who highlights the impact of tacit knowledge among practitioners on the success of policy initiatives. Similarly, Price et al. (2012) stress the importance of technical interventions, such as pressure management and the reduction of water loss, which are essential for regulatory frameworks to ensure sustainable water services. Both studies assert that effective regulation must incorporate both technical and knowledge-based strategies to yield practical outcomes. Jonker (2012) and Pienaar et al. (2017) converge on the significance of economic and environmental factors within regulatory frameworks, particularly in relation to industrial water usage and transitions towards a green economy. They propose that water demand planning should be aligned with broader economic strategies and environmental policies. Earlier, Mwendera et al. (2003) contend that resource limitations and stakeholder engagement represent significant barriers to effective WDM regulation, reinforcing the notion that regulatory policies must address both technical dimensions and socio-economic and institutional challenges.

3.4. Strategies that have been used by institutions that have made headway in the regulation of water demand planning in SA

Institutions in SA that have effectively regulated water demand planning have utilized a range of strategies that incorporate both technical and participatory methodologies. Price et al. (2012) provide an account of the Nelson Mandela Bay Municipality's successful implementation of water loss reduction initiatives, which included network calibration, leak detection, and pressure management. These interventions contributed to sustainable water service delivery by minimizing unbilled consumption. Jonker (2012) underscores the application of economic analysis in optimizing water management for power generation, focusing on cost-effective cooling systems that align with national water planning objectives. Similarly, Pienaar et al. (2017) examine the employment of system dynamics models in the Western Cape, where strategic interventions to facilitate a transition to a green economy were integrated with effective water demand planning, promoting sustainability through comprehensive resource management. Meanwhile, Mwendera et al. (2003) highlight the importance of raising awareness and building capacity among stakeholders to address challenges in WDM. They assert that effective institutions have prioritized the promotion of understanding regarding the advantages of WDM across various sectors, thereby improving compliance and overall effectiveness.

3.5. Interventions and strategies for improving the regulation of water demand planning in SA

A prevalent theme in the literature concerning interventions and strategies aimed at enhancing the regulation of water demand planning in SA is the integration of technical solutions with community engagement and the strengthening of institutional capacities. Price et al. (2012) concentrate on technical interventions, including pressure management, leak detection, and the reduction of water loss, as means to promote sustainable water services. Wolfe (2009) underscores the significance of incorporating tacit and explicit knowledge among practitioners, positing that training and knowledge-sharing are crucial for improving regulatory practices. Mwendera et al. (2003) highlight the necessity of fostering stakeholder awareness and engagement to address

regulatory and resource-related challenges, advocating for enhanced collaboration between communities and regulatory bodies. Similarly, Pienaar et al. (2017) promote systemic approaches, such as applying dynamic models to forecast water demand within a green economy's framework, ensuring that planning efforts are aligned with broader environmental objectives. These studies indicate that effective regulation is contingent upon a synergistic combination of technical strategies, stakeholder participation, and institutional development.

In the context of a research initiative focused on obtaining insights and recommendations from professionals for the formulation of a WDM Strategic Plan in the Vhembe District Municipality (VDM), participants were posed the question, "Are there supporting statements in the by-laws of the Vhembe District Municipality that facilitate Water Demand Management Strategic Planning?" The researchers utilized Microsoft Excel to systematically organize, manage, tabulate, and graphically represent the individual responses collected from open-ended, semi-structured interviews. Coding of the interview data was done (Table 3). Thematic analysis was employed to explore both semantic and latent themes (Braun & Clarke, 2006). The semantic analysis focused on the explicit or surface meanings of the data, with the researcher refraining from seeking interpretations beyond the direct statements made by participants or the written content. In contrast, the latent approach aimed to identify and examine the underlying ideas, assumptions, conceptualizations, and ideologies that are believed to influence the semantic content of the data (Braun & Clarke, 2006:84).

Table 3. Table of codes from the interview data

Data	Code
By-laws need to be adopted	Poor Implementation
By laws facilitate water demand planning	Regulation
by-laws are subject to periodic review based on prevailing circumstances	Regulation
several by-laws have been established	Regulation
uncertainty regarding whether the provisions of these by-laws explicitly pertain to water demand planning	Poor Implementation; Lack of communication
there are by-laws that address various elements related to water demand planning initiatives	Regulation; Integrated planning
several by-laws have been established to address the issue of illegal water connections	Regulation
the VDM has established by-laws, these regulations are not actively enforced	Enforcement
there is a lack of specific legal provisions addressing particular infractions, such as the use of illegal water connections	Comprehensiveness
the existing by-laws related to WDM within the VDM are sufficient	Regulation

Source: Authors' creation

All interview participants unanimously concurred that the by-laws of the VDM contain provisions that facilitate WDM Strategic Planning. This assertion is corroborated by existing literature, which indicates that water resource management in SA has been hampered by institutional uncertainties, challenges related to policy compliance, and declining water quality, suggesting that there are initiatives aimed at formulating by-laws that support WDM within municipalities like VDM however, these municipalities may be perceived as lacking proactive measures in developing such by-laws due to significant policy challenges, including institutional uncertainties, compliance issues, and the deterioration of water quality (Adom & Simatele, 2024).

One participant in the interview indicated that the by-laws of the VDM facilitate water demand planning; however, the participant expressed uncertainty regarding the current adoption status of these by-laws.

Additionally, the participant noted that the by-laws are subject to periodic review based on prevailing circumstances. This is supported by the literature, with Ruiters and Amadi Echendu (2022) indicating that SA's water regulation is hindered by issues such as under-pricing, suboptimal returns on capital investment, elevated levels of non-revenue water, and a considerable gap in capital investment. These factors suggest a deficiency in funding necessary to facilitate and sustain the expenses associated with the proposal, adoption, and implementation of by-laws pertaining to water demand planning, thereby undermining the efficacy of the processes associated with these regulations.

One interview participant indicated that several by-laws have been established to address the issue of illegal water connections. The participant expressed uncertainty regarding whether the provisions of these by-laws explicitly pertain to water demand planning; however, they noted that there are by-laws that address various elements related to water demand planning initiatives. One participant noted that while the VDM has established by-laws, these regulations are not actively enforced. This participant further indicated a lack of specific legal provisions addressing particular infractions, such as using illegal water connections. Conversely, another participant asserted that the existing by-laws related to WDM within the VDM are sufficient, a claim corroborated by existing literature. The inability to enforce current by-laws pertaining to WDM and the failure to prosecute individuals who violate these regulations can be directly attributed to a deficiency in knowledge regarding WDM. As previously discussed in this study, seven studies from the literature review highlight the significance of WDM knowledge, with some, such as Daane (1998), emphasizing that a comprehensive understanding of WDM is essential for making informed strategic investment decisions. Additionally, Price et al. (2012) underscore the existing gaps in education related to water conservation, while Mathipa and Le Roux (2009) illustrate that participants in their research demonstrated a lack of practical knowledge regarding WDM strategies, thereby highlighting the critical role of knowledge in promoting effective water conservation practices.

4. Discussion of findings

The interview findings conveyed doubts about the existing adoption status of by-laws that facilitate water demand planning within the VDM. It was also revealed via the interview findings that existing by-laws in the VDM do undergo regular reviews in response to changing conditions. This assertion is corroborated by the rapid review data, with Ngcobo et al. (2023) indicating that income levels consistently influence the uptake of water-efficient practices. Additionally, Murwirapachena (2021) emphasizes the challenges related to water demand planning initiatives, noting that biographical factors generally do not significantly affect the adoption of water-efficient appliances. The regulation of water demand planning in SA encounters several challenges, including unsustainable water consumption, insufficient infrastructure, rapid urbanization, corruption, and inadequate stakeholder engagement. SA is currently facing issues related to water scarcity, with an anticipated increase in water demand of 17% by the year 2030. Furthermore, it is noteworthy that 37% of urban piped water is lost, underscoring the urgent necessity for effective water management strategies. In 2017, a significant rise in intermittent water supply affected approximately 22 million individuals in SA, highlighting the pressing demand for water services within the nation.

Tacit knowledge is instrumental in influencing WDM practices and their effective execution. A comprehensive understanding of WDM is essential for making well-informed strategic investment choices. Current educational shortcomings related to water conservation indicate a pressing need for developing awareness campaigns to enhance understanding of WDM. Furthermore, the deficiency of practical knowledge regarding WDM strategies highlights the critical role of knowledge in promoting effective water conservation behaviours. Integrating technical solutions with institutional and stakeholder engagement is essential for attaining sustainable water management. Technical interventions in managing water resources, including pressure management and the reduction of water loss, are necessary to enforce regulatory frameworks that promote sustainable water services. To achieve practical outcomes, effective water demand regulation must incorporate technical and knowledge-

based strategies. Furthermore, economic and environmental factors are significant components of regulatory frameworks, especially in relation to industrial water usage and the transition towards a green economy.

Institutions in SA that have effectively managed water demand planning have utilized a range of strategies that incorporate both technical and participatory methodologies. For instance, the Nelson Mandela Bay Municipality has adopted water loss reduction initiatives, including network calibration, leak detection, and pressure management. These interventions have facilitated sustainable water service delivery by minimizing unbilled consumption. Additionally, the application of system dynamics models in the Western Cape has proven beneficial, as it has connected strategic interventions aimed at transitioning to a green economy with effective water demand planning, thereby promoting sustainability through holistic resource management. The cornerstone of all strategic planning in the water services sector is the forecasting of water demand, which seeks to project the future water requirements of the designated planning area. Forecasting water demand plays a significant role in enhancing early warning systems and improving the assessment of financial service delivery performance by anticipating future growth in water demand. Accurate water demand estimation and forecasting are essential for projecting income, planning infrastructure capacity, and formulating strategies to gradually or rapidly decrease demand in response to drought conditions.

Nonetheless, it is critical to acknowledge the high uncertainty associated with water demand forecasting, particularly over extended timeframes. This uncertainty can be alleviated by implementing anticipatory governance, which enhances the efficiency of the forecasting process. Integrated water resource planning effectively consolidates the uncertainties related to both water demand and supply within a cohesive anticipatory governance framework (Quay, 2015). By embracing the notion of conceptualizing policy as an experimental process, which recognizes the potential for unforeseen results during its execution, the model illustrated in Figure 2 seeks to establish a basis for predicting water balances within the VDM (Quay, 2015). Water balances within the VDM can be projected and assessed, as precisely forecasting water demand and supply is often challenging. These estimates provide insights into the actual conditions on the ground, thereby facilitating improved planning efforts.

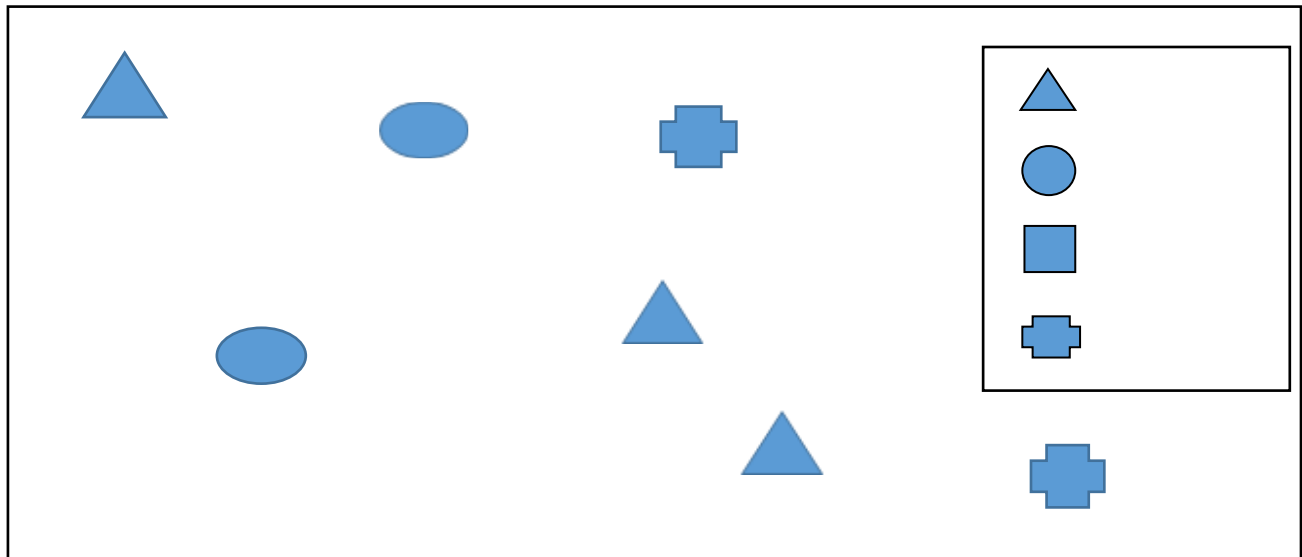


Fig. 2. Water balance forecasting model

Source: Mukonavanhu, 2022

The data obtained from interviews and a literature review on WDM facilitated the creation of a Water Balance Forecasting Model. This model is aligned with the principles of Integrated Water Resource Planning theory.

Utilizing the model depicted in Figure 2, it is possible to generate forecasts for all regions equipped with water meters, thereby estimating their respective water balances. The information collected from these metered regions can subsequently be employed to approximate water balances in areas lacking water meters through techniques such as ratio analysis. As a result, a holistic estimate of the water balance for the entire system can be derived by aggregating estimates from all water usage points. For additional water reservoirs, estimates can be generated using straightforward ratios, such as 1:1, considering size, water capacity, and local demographics. This methodology can be applied to all regional water usage points, encompassing industrial and domestic water consumption. For instance, if one dam provides 300 megalitres of water monthly to a population of 500,000, a comparable estimate can be derived for another dam serving 300,000 individuals by employing a 1:1 ratio to calculate the estimated water usage for the second dam. The following simple formula would be utilized in such scenarios:

$$\frac{300\,000}{500\,000} \times 300$$

Water demand and supply exhibit a natural unpredictability and volatility. Forecasting aims to deliver the most dependable estimates for effective planning. Employing a range of scenarios makes it possible to anticipate various outcomes, facilitating the adjustment of plans to align with real-time conditions as they emerge. As time progresses, the precision of these forecasts is expected to enhance by establishing a thorough framework that leverages online databases encompassing multiple factors affecting WDM. Elements such as population dynamics, climate variations, cultural influences, infrastructure development, and household characteristics, among others, significantly affect water demand and supply.

To effectively regulate water demand, there is a need to comprehend how much water is present in the drainage basin presently as well as how much water will be available in the near future as well as in the distant future. This will help regulators to adopt and formulate flexible and responsive plans that align with current and future water demand patterns. For example, the knowledge that there will be higher water demand in the coming season or years will help regulators to formulate policy that helps to reduce water loss or water use, such as increasing tariff rates or introducing stricter penalties for criminals caught illegally connecting to water sources.

The Water Balance Forecasting Model is designed to enhance the forecasting of water demand, a critical component of any water management strategy. This model assesses the volume of water needed in a designated area over various timeframes, including days, months, or years. The forecasting methodology employed can be linked to the Integrated Development Plan (IDP) and its alignment with Medium Term Expenditure Frameworks (MTEF). The MTEF emphasizes budgeting over three years to optimize financial management (Musoma et al., 2016). The elements included in the Water Balance Forecasting Model are detailed in the following sections:

Reservoir: The proposed Water Balance Forecasting Model aims to enhance the estimation of water volumes in reservoirs lacking metering systems, thereby addressing the challenges faced by the VDM regarding unmetered reservoirs and water tankers. Furthermore, this model will enable the VDM to refine its assessments of water consumption. A considerable amount of water distributed to communities within the VDM remains unrecorded, largely due to complications associated with metering and billing processes. In certain areas of the VDM, there are no records of the water extracted, and metering is only conducted at the command reservoir (Vhembe District Municipality, 2024).

Sanitation Plant: The apartheid era resulted in disparities in sanitation services between rural and urban regions. The Water Balance Forecasting Model can assist the VDM in monitoring the development and expansion of sanitation facilities (Brauns & Stanton, 2016). This will assist the VDM in tracking advancements in sanitation service provision per the IDP's objectives of diminishing the water access disparities resulting from

discriminatory apartheid policies (Cole et al., 2018). This further aligns with one of the main goals of the WDM, which emphasizes the importance of water conservation and the promotion of social development (Isbell, 2020).

Household: The suggested Water Balance Forecasting Model can enhance the VDM's ability to estimate Non-Revenue Water (NRW) more precisely by utilizing data from metered households to infer water consumption in unmetered ones. This methodology can further aid in developing policies designed to lower overall water usage among households. Moreover, the model may facilitate more effective water distribution, which could reduce water waste and increase supply for households lacking piped water. Enhanced estimations of household water consumption can also play a crucial role in establishing equitable and accurate water tariffs, thus decreasing NRW (Vidal-Lamolla et al., 2024).

Industry: The suggested Water Balance Forecasting model promises to improve accountability in the industrial sector by enabling more precise assessments of water consumption in industries. Such advancements could result in greater efficiency in the utilization of water resources, thereby encouraging innovation and promoting water conservation. This, in turn, may stimulate economic growth through enhanced operational efficiency and innovative practices, aligning with the objectives of fostering efficiency and effectiveness in the public sector. Additionally, the model's dependence on online databases for collecting and distributing data related to industrial water usage can significantly improve communication and information sharing.

Conclusions

Improving water resource management necessitates adopting water demand planning, which facilitates sustainable utilization of water resources. As an essential management function, planning is integral to the fundamental operations of any organization. It enables organizations to manoeuvre through intricate and competitive landscapes effectively. During periods of difficulty, strategic planning becomes paramount in guiding decision-making processes. The benefits of planning are numerous, encompassing the establishment of the organization's strategic direction, the alignment of activities with objectives and outcomes, the enhancement of collaborative efforts, the anticipation of both expected and unexpected challenges, the promotion of adaptability to change, and the provision of a robust foundation for informed decision-making.

This research offers a thorough analysis of the challenges that impede effective regulation of water demand planning in South Africa, specifically focusing on the Vhembe District Municipality. The results indicate that, although supportive by-laws and strategic frameworks are in place, the implementation is lacking due to institutional uncertainties, insufficient enforcement, limited engagement from stakeholders, and considerable knowledge deficiencies among practitioners. The originality of this study is found in its combination of a swift literature review with qualitative insights gathered from municipal managers, providing a triangulated viewpoint that connects theoretical knowledge with practical situations. Additionally, the creation of the Water Balance Forecasting Model signifies a notable practical advancement. This model improves the precision of water demand forecasts in metered and unmetered regions and facilitates anticipatory governance and integrated planning. Its utilization can enhance financial planning, infrastructure development, and fair water distribution, especially in municipalities facing resource constraints. By aligning water demand forecasting with broader developmental frameworks such as the Integrated Development Plan (IDP) and the Medium-Term Expenditure Framework (MTEF), this study offers a replicable resource for municipalities throughout South Africa to fortify their water governance systems and encourage sustainable management of water resources.

Implications, limitations and recommendations

The research findings present several implications for policy-making and decision-making in local government. Forecasting water demand in local government is essential for strategically planning water services. The Water Balance Forecasting Model developed in this research provides inputs to policy-making to integrate WDM into local government and to aid decision-making and strategic planning in local government.

A limitation of the study is that it focuses on a single case study. However, this is sufficient as this research is qualitative and does not seek to generalize and replicate findings but to understand and interpret a specific reality within a particular context, such as in the Vhembe District Municipality. However, future research on different case studies comparing rural versus metropolitan municipalities will provide useful evidence-based data for policy-making.

WDM significantly improves coordination, strategic development, and financial performance in municipal water services, and therefore, it should be vigorously promoted within the framework of the VDM. It is essential to strengthen the coordination and alignment of WDM initiatives to enhance transparency, accountability, and the sharing of knowledge and skills. Furthermore, the VDM should support a unified, comprehensive development plan that incorporates all pertinent strategies, including WDM, while ensuring that the municipality's current resources and capabilities effectively align with the implementation process.

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