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Towards an approach for enhancing water security: The case of South Africa

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Background: Water demands in South Africa are rising, yet there is a lack of frameworks addressing sustainable water security at the local level. This gap, compounded by limited empirical evidence, challenges efforts to enhance water security.

Aim: The article assesses water security and proposes a localised and adaptive framework for long-term water security at the household level in South Africa, aligning with sustainable development and integrated water resource management principles.

Methods: Fieldwork, based on mixed methods approach, was conducted and a review of relevant literature was undertaken to identify fundamental dimensions of water security.

Results: Critical elements influencing water security (viz. grouped into five dimensions: economic, social, technical, environmental, and institutional) were observed. An approach, based on the critical elements pertaining to water security, was developed to address the relevant dimensions, offering an integrated approach to enhancing water security.

Conclusion: The proposed framework advances an understanding of water security by offering a novel and actionable approach that can be adapted to local contexts in South Africa (and possibly in other countries too). It emphasises the importance of multi-dimensional solutions to enhance the resilience of local water supply systems.

Contribution: This article fills a significant gap in local-level water security frameworks, providing a practical model for policymakers and stakeholders to implement sustainable water security strategies in South Africa.

Keywords: sustainable water security; integrated water resource management; descriptive model; sustainable development; localised framework.

Introduction

Assessing sustainable water security is essential for effective water resource management (Gerlak, Mukhtarov & Tarlock 2018), as it helps to identify the range of challenges that must be addressed to achieve water security (Hjorth & Madani 2014). Scholars have proposed various methodologies and index systems for evaluating water security through the lens of sustainable development's triple bottom line. A comprehensive assessment should employ a set of sustainability indicators that clearly define the concept (Huimin et al. 2019). This evaluation is crucial for distilling broader water-related issues and aligns with Sustainable development goal (SDG) 6, which aims to ensure universal access to clean water and sanitation (United Nations 2015). Despite prior studies highlighting challenges (Biswas & Tortajada 2019; Global Water Partnership [GWP] 2014), there is a significant lack of empirical evidence regarding long-term water security frameworks at the household level. A systematic assessment framework is necessary to evaluate current conditions and progress towards sustainable water management goals. Many studies emphasise the urgent need for a local-level framework for sustainable water security (Srinivasan, Konar & Sivapalan 2017). Although achieving long-term water security at the household scale is increasingly complex, assessments remain inconsistent both spatially and temporally. Since the impact of water shortages is often first experienced at the household level, establishing a thorough, locally focused framework for sustainable water supply is vital (Hailu, Tolossa & Alemu 2020).

Koontanakulvong (2019) emphasises that the effectiveness of strategic water administration, water efficiency, and the provision of water supply and sanitation services are essential for long-term water security. From a sustainability perspective, nearly all social and economic activities require long-term water security to support human life (Vila et al. 2018). This issue is complex, as achieving sustainable water security while addressing societal and environmental needs necessitates collective responses

that reflect the realities faced by communities. According to Kusuma and Octastefani (2016), fostering long-term water security and ensuring water self-sufficiency for present and future generations requires communities to adopt a cooperative spirit for effective water management. A collaborative approach enables individuals to pool resources and encourages active participation, fostering a sense of ownership in the outcomes. Babel, Shrestha and Rivas (2016) argue that sustainable water security should be interrogated at the household scale, with access to improved water supply serving as a key indicator. Indeed, long-term water security – ensuring a reliable provision of safe water while minimising natural resource waste – presents one of society's greatest challenges (Durán-Sánchez et al. 2018). Thus, it is essential to integrate sustainability into all aspects of water management to achieve water security.

It is in this context that an attempt is made through this article to propose an approach that can enhance water security in South Africa. The article commences by giving a background or context to sustainable water security and other attempts aimed at ensuring water security. That is followed by a discussion of pertinent conceptual and theoretical issues. Then follows a sections that explain research methods and design, discussion of the empirical results and findings. The article then presents the proposed model and its applications, an argument for an approach to water security, and finally, the conclusion.

Background

Over the years, various frameworks, approaches, and tools have been developed to assess and explore water stability at different levels (Marcal, Torres & Ferreira 2021a). These frameworks incorporate key features of water security (Krause 2015; Lombana, Amaya & Ortega 2021), including ensuring water availability and effective wastewater treatment. A notable example is the UNDP-proposed Water Security Framework, which considers six aspects of water stability: accessibility, standard, governance, efficiency, and ecological sustainability. Another significant framework is the human right to water framework developed by World Health Organization (WHO) and UNICEF, which asserts that everyone has the right to safe drinking water. In addition, the Stockholm Environment Institute's (SEI) Nexus Approach Framework aims to enhance resource sustainability by integrating policies across energy, food, and environmental sectors. Despite the existence of these frameworks, several deficiencies have been identified in their implementation and effectiveness. While they address essential elements such as water availability and wastewater treatment efficacy (Krause 2015; Lombana et al. 2021), their practical application is often limited. Furthermore, existing frameworks frequently do not sufficiently address the dynamic and context-specific challenges faced by local communities. Therefore, further research is needed to develop adaptive and localised assessment frameworks that can be tailored to specific contexts while maintaining a consistent and comprehensive approach to water security.

It seems that there is no widely accepted method for assessing water security, primarily because of the concept's ambiguity and varying understandings. However, water stability can be articulated through indicators or frameworks that aid in evaluation and improvement efforts (Marcal et al. 2021). Currently, there is no consensus on how to identify and implement frameworks that enhance water security, particularly at household scale (Aboelnga et al. 2019). As a result, assessments of water security differ significantly, consisting of frameworks reinforcing risks while others focus on the need to expand water resources to accommodate growing populations (Garrick & Hall 2014; Giordano 2017). Conversely, societies are increasingly aware that the long-term viability of water usage depends on sustainable water security. By adopting an integrative and adaptive framework, stakeholders can effectively assess and enhance water security at the local level, ensuring a more sustainable and resilient water supply system. There have also been efforts to develop frameworks that evaluate water stability, especially at national and global scales (Collier et al. 2014; Fagan, Reuter & Langford 2010; Hellström, Jeppsson & Kärrman 2000). However, these frameworks often do not address the assessment of water security at the local scale. Despite their limitations in practical application at the local level, they provide a valuable foundation for developing new frameworks.

Sustainable water security is an increasingly specialised area of research for scholars worldwide. Evaluating long-term water security at the household scale is essential, as it captures the diverse dynamics associated with water security and effectively addresses water-related challenges. At its core, a sustainable water security assessment intends to guarantee the long-term and potable water for various uses through the engagement of all relevant stakeholders (Frone & Frone 2013). This assessment framework allows policymakers to gain a deeper understanding of current long-term water security challenges. Jaeger et al. (2013) emphasise the necessity for a framework that evaluates long-term water stability at household scale. However, there is a significant lack of a comprehensive, multidimensional model of long-term water stability at the household scale in many African nations, particularly in South Africa (Hailu et al. 2020). This article addresses this gap by introducing an innovative analytical framework that tackles existing research deficiencies, making a significant academic contribution as the first of its kind and providing valuable insights to the field.

Conceptual and theoretical issues

Ensuring that every citizen and society has reliable access to an adequate supply of safe water is the fundamental element of water security and aligns with principle of SDG 6, which aims to ensure availability of water and sanitation for all. This includes meeting household needs for consumption, cooking, and hygiene, as well as the operational requirements of businesses (UNESCO 2019). Additionally, water security involves ensuring that available water meets acceptable standards and is potable

for uses. At the household level, water security is generally characterised by the consistent availability of an adequate amount of safe water necessary for maintaining a healthy and productive life for all individuals. This encompasses three fundamental dimensions: the presence of water, the ability to obtain it, and the capacity to utilise it, akin to the concept of food security (Ringler et al. 2015). Achieving water security has become a crucial global challenge because of inadequate water resource management and increasing pressures from climate change, population growth, shifting lifestyles, and economic development (Pokhrel et al. 2021; Wang et al. 2018). As emphasised by UN SDG 6, the importance of ensuring the availability and sustainable management of water is critical, particularly for rural communities facing severe water challenges (UN 2015).

South Africa faces significant water challenges, particularly in rural areas. Tapela (2018) highlights that the difficulties in maintaining safe water distribution and sanitation services in these regions are widespread. These challenges not only threaten public health and agricultural productivity but also hinder progress towards SDG 6, which emphasises the necessity of safe water and sanitation. In addition, these issues indirectly impact SDG 14 by degrading aquatic ecosystems because of poor water management practices (United Nations 2015). The lack of water resources at the household level in rural areas poses substantial risks to human well-being and critical sectors such as food security (Mabhaudhi, Chimonyo & Modi 2018). Climate change represents one of the most significant threats to South Africa's water supply, leading to rising temperatures, erratic rainfall patterns, and increased occurrences of droughts and floods (Hemson 2016; Rankoana 2016). These volatile climatic conditions create challenges for households in accessing reliable water sources. Ramifications of climate change on water resources are expected to exacerbate existing difficulties and create new challenges for rural communities (Mutumba 2019).

The availability of safe drinking water is essential for human survival, making water security a pressing global concern. Natural hazards such as floods and droughts threaten hundreds of millions of people who lack access to safe drinking water, reliable water sources or adequate sanitation (Global Water Strategy, 2017). At the current growth rate, the World Bank predicts that by 2050, 5 billion people will be living in river basins where water is scarce, up from an estimated 3.5 billion in 2025. This situation forces millions of individuals to struggle daily for access to potable water. According to the World Resources Institute (2023), global water demand is expected to increase by 20% to 25% by 2050. This surge is likely to lead to severe water stress for a significant portion, if not the entirety, of the population in the Middle East and North Africa by that time. Therefore, if current trends continue, a substantial fraction of the global population could find themselves residing in regions facing acute water scarcity in the coming years.

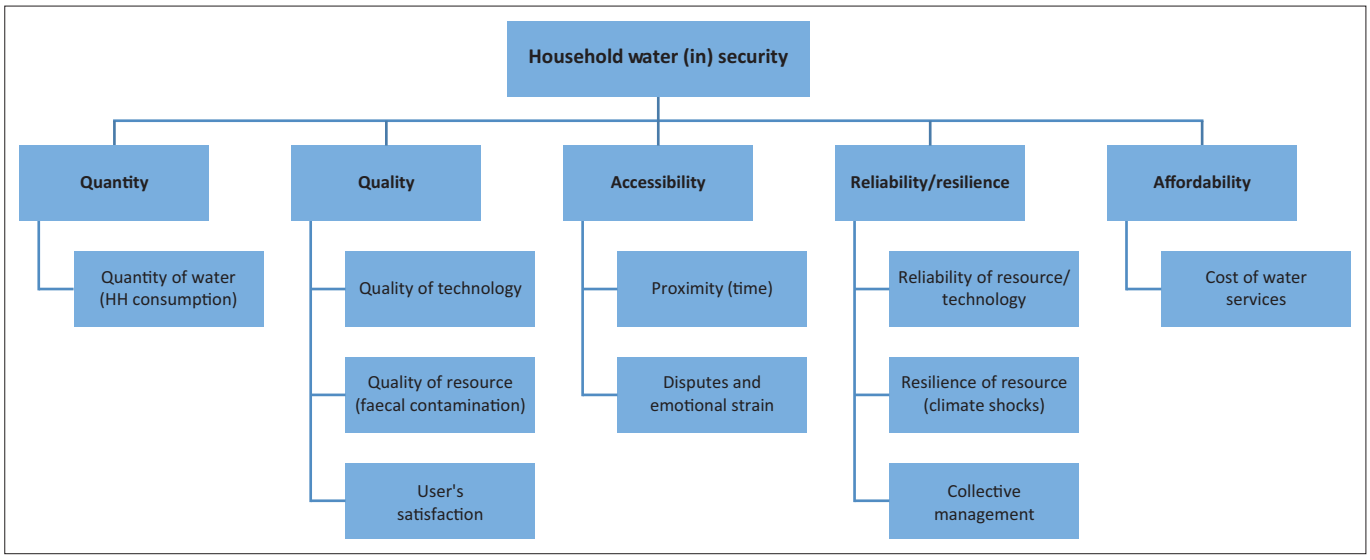
The concept of water security has gained increasing recognition of late, both in academic discussions and in policymaking contexts. There are various definitions and interpretations of water security that differ across disciplines, regions, and themes (Honkonen 2017). Water security is a concept frequently utilised in academic, policymaking, and the general public (Marttunen et al. 2019). Water security is crucial for human society, impacting all levels, from individuals and households to communities and broader national, regional, and international frameworks (Habiba & Shaw 2014). According to Besbes, Chahed and Hamdane (2018), water security has been defined in numerous ways; however, one of the most frequently used definitions is provided by Grey and Sadoff (2007), who characterise it as the provision of sufficient quality and quantity of essential water resources, human welfare, and environmental health, alongside a controllable level of water-related risks to individuals, ecosystems, and economies. To implement the concepts of water security, Thomas (2015) categorised 10 measurable variables into five classifications: 'quantity', 'quality', 'accessibility', 'reliability or resilience', and 'affordability' (refer to Figure 1).

Research methods and design

The article is based on a study conducted in the Bojanala District, located in the North West province of South Africa. Home to a diverse population, the district covers an area of approximately 18 333 square kilometers. Multiple factors, including geographical features, population growth, economic activities, and climate change impact water security of the district. Water resources from rivers, dams, and underground aquifers are relied upon by the district. However, its semi-arid climate and irregular rainfall patterns significantly affect the availability and reliability of these water sources. Droughts and water scarcity are common challenges, especially during dry periods, complicating efforts to ensure a long-term and secure water supply for its residents. Moreover, intensifying climatic conditions, changing precipitation patterns, and an increased frequency of severe climatic events further threaten water availability and exacerbate water scarcity in the region.

The article employed a cross-sectional, descriptive research design to analyse water security through a multi-dimensional approach, incorporating economic, social, technical, environmental, and institutional factors. This design is particularly effective for exploring water security because it allows for the simultaneous analysis of multiple variables that influence access and quality of water resources. Previous research in similar contexts has shown that descriptive designs facilitate the understanding of complex interactions between social, economic, and environmental factors impacting water availability (Aboelnga et al. 2020; Dube 2020).

The study applied a stratified random sampling strategy, ensuring that the sample of 384 respondents drawn from a



Source: Thomas, J.M., 2015, 'Assessing household water security: Indicators and methodology', *Journal of Water Resources Planning and Management* 141(2), 1–13

FIGURE 1: The dimensions of household water security.

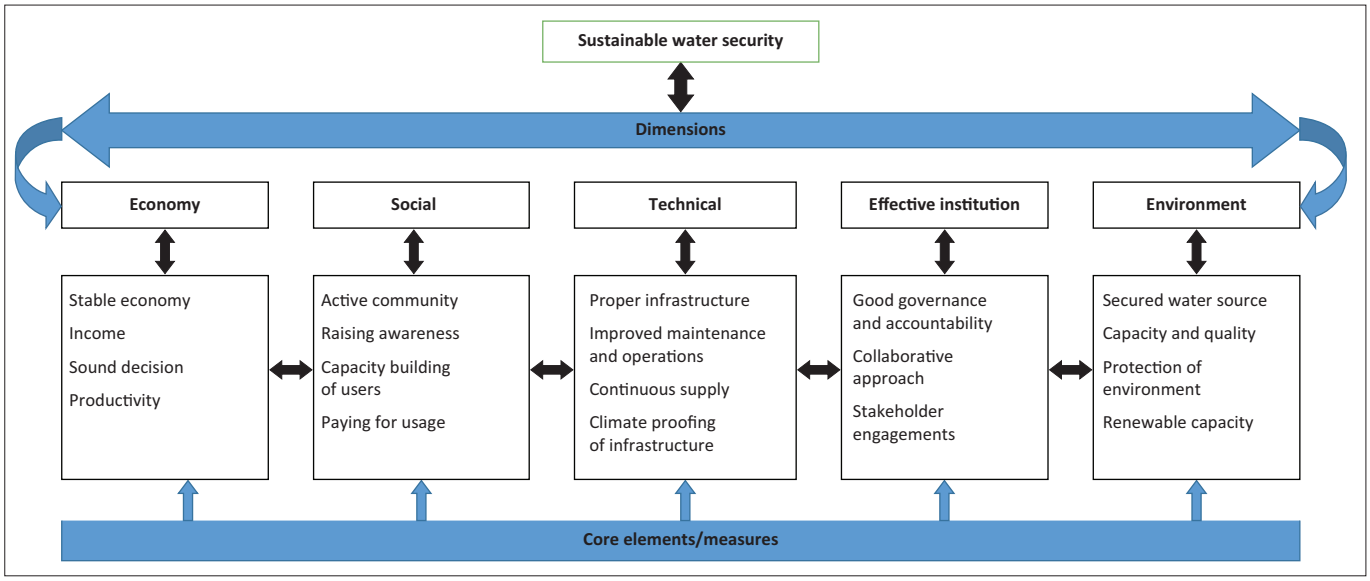


FIGURE 2: Proposed model for sustainable water security.

total of 611, 145 individuals accurately reflects diverse subgroups within the population of Bojanala District. Strata were defined based on geographic regions, income levels and population growth. Stratified sampling is essential in heterogeneous populations to capture the variations in experiences and perceptions regarding water security (Creswell & Plano Clark 2011). The 1970 model of Krejcie and Morgan (1970) was used to determine a sample size of 384.

The 384 respondents were selected and interviewed using a quantitative approach. Data were collected using a structured questionnaire designed to assess key indicators of water security. Structured questionnaires are effective tools for quantitative research, allowing for the collection of standardised data that can be easily analysed (De Vaus 2013). The questionnaire was pre-tested in a pilot study involving lesser group of people (8) residing in the district to enhance clarity and ensure validity, thereby increasing its overall reliability. Pre-testing the questionnaire, as conducted in this study, is a best practice that enhances the clarity and relevance of survey items (Dillman, Smyth & Christian 2014). Previous studies have successfully utilised similar tools to investigate water security issues, demonstrating the reliability of this method in generating valuable data (Maganda 2016; Mishra et al. 2021).

Descriptive statistics and regression analysis were employed to enhance the understanding of water security in the district. Descriptive statistics furnished an inclusive overview of the demographic characteristics of respondents and key indicators of water security (Field 2013). Regression analysis facilitates the examination of associations between independent and dependent variables, thereby allowing for the identification of significant predictors of water security (Cohen et al. 2013). This analytical framework has

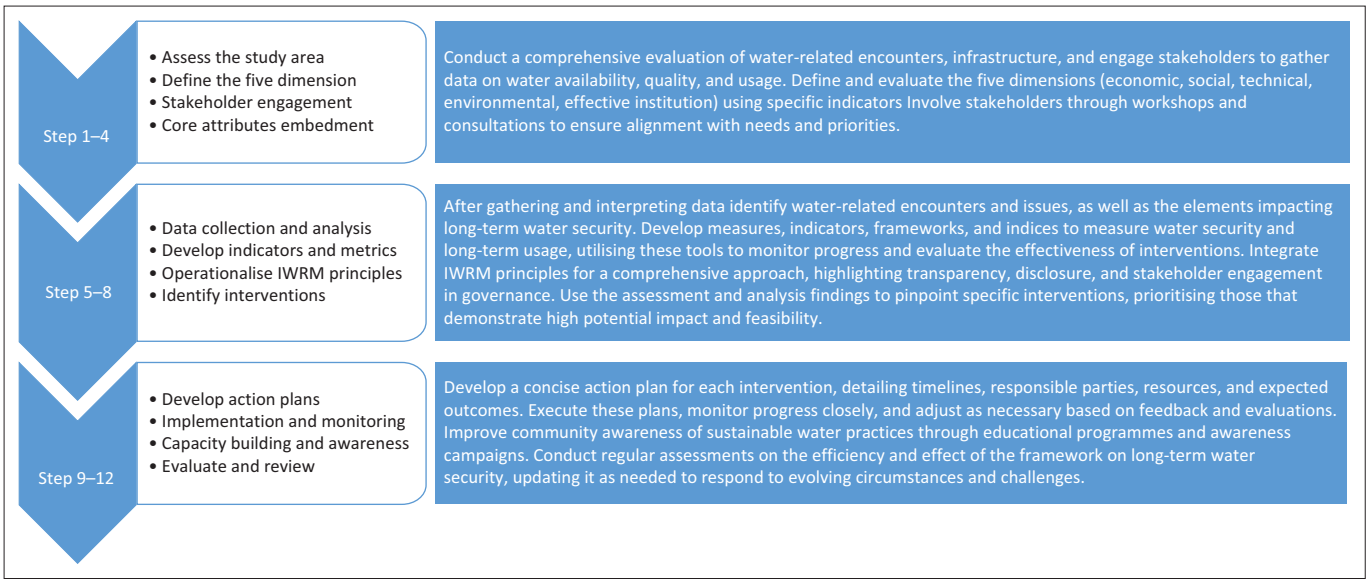


FIGURE 3: Proposed implementation of the model.

been effectively applied in prior studies addressing similar subject (Dube 2020). Furthermore, a literature review was conducted to complement the empirical data and to contextualise the diverse challenges surrounding water security. Research has demonstrated that literature reviews are essential for understanding the broader implications of research findings and for situating these findings within existing theories and frameworks (Fink 2019).

The factors affecting sustainable water security among households were analysed using a logistic regression model. The logit (see Equation 1) of a value p that falls between 0 and 1 can be expressed using the following formula:

$$\text{logit}(p) = \log\left(\frac{p}{1-p}\right) = \log(p) - \log(1-p) = -\log\left(\frac{1}{p} - 1\right) \quad \text{[Eqn 1]}$$

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of South Africa College of Human Science Ethics Committee (reference number 37346423_CREC_CHS_2021). Thus, this study was carried out in accordance with the University Research Ethics standards and guidelines.

Data analysis and discussion

This section presents and discusses the study's findings. Table 1 gives descriptive statistics that summarise the respondents' demographic and socio-economic characteristics.

The findings are consistent with prior research on water insecurity in rural and semi-urban areas of South Africa. A total of 384 respondents were interviewed. Supporting the findings of Sharaunga and Mudhara (2020), it is evident that the number of individuals living in a household significantly affects the long-term reliability of access to clean water. As Table 1 shows, which is in line with findings of Dotse (2016) that households with many inhabitants have more individual water needs.

Another important finding in this article is that 31% of respondents described that their water source is situated over 200 m from their residences, with inadequate water pressure. This aligns with the study of Majuru, Jagals and Hunter (2012), who found that individuals in rural South Africa may need to walk 600 m or more to access water. Similarly, Geere and Cortobius (2017) emphasised that long distances to fetch water present significant obstacles to sustainable development and domestic water security.

Most importantly, over 50% of respondents reported that water quality is poor. Put differently, only 17.4% of respondents said that the water quality is good and very good. This aligns with Ncube et al. (2021), who found that many households conveyed concerns about the safety of their drinking water, with substantial percentages indicating issues such as turbidity and contamination. Empirical research indicates that insufficient treatment facilities and ageing infrastructure contribute significantly to the perceptions of poor water quality. For instance, the National Business Initiative reported that a lack of reliable municipal services affects the quality of drinking water supplied to many households in Bojanala (National Business Initiative 2018).

Furthermore, 81.8% respondents conveyed a need for a new water model that can assist in sustainable water security. This aligns with Bolognesi et al. (2018), who found that in regions confronted with water scarcity, the development of innovative water management models is critical to guarantee long-term access to water resources. Linking this with what other studies found, we have identified five fundamental dimensions of long-term water security that are common in nature, with their measurement based on various elements. Relevant dimensions and elements were crafted upon an extensive review of the literature.

TABLE 1: Demographic and socio-economic characteristics of respondents (N = 384).

Variables	Descriptions	%
No. of dependents	1–4	48.2
	5–8	48.2
	9–12	3.6
Age (years)	19–29	28.2
	30–40	32.6
	41–51	22.9
	52–62	13.9
	63 ≥ above	2.4
Head of household	Yes	52.9
	No	47.1
Employed	Yes	54.9
	No	45.1
Monthly income	≤ R500	6.8
	R501–R1500	12.5
	R1501–R2600	29.0
	R2601–R3500	11.5
	R3501–R6400	20.8
	R6401–R10 000	8.6
	≥ R10 000	11.5
Education level	None	0.8
	No formal education	23.0
	Primary (Grade 1–7)	15.0
	Secondary (Grade 8–12)	51.8
	Certificate	19.3
	Diploma/Degree	7.6
	Honours/B-Tech	1.3
	Masters	1.6
	PhD	0.3
Distance to the near water source	≤ 50 m	19.6
	51 m– 100 m	23.5
	101 m – 150 m	11.7
	151 m – 200 m	14.2
	≥ 200 m	31.0
Own a private tap	Yes	58.2
	No	41.8
Disagreements	Water scarcity	22.5
	Long ques	3.7
	Low water pressure	3.4
	Poor maintenance	2.6
	Source	-
Water quality	Very poor	30.2
	Poor	26.6
	Fair	25.8
	Good	13.0
	Very good	4.4
Water awareness	Yes	20.8
	No	79.2
Water model required	Yes	81.8
	No	18.2

No., number.

We advocate for an integrated method that is consistent with sustainable development principle and IWRM. The proposed model is a conceptual framework designed to capture intricacies and dynamics of long-term water security. It incorporates a thorough analysis of parameters, framework, indicators, and tools for gauging water stability and long-term water use, drawing from both local and international research. By critically reviewing existing studies, the researchers ensured that their model offers new insights and contributions to the field, rather than duplicating previous work.

Proposed model

The proposed model, as illustrated in Figure 2, adopts a multidimensional approach to guarantee the long term availability and accessibility of water across natural, social, and economic systems. It presents an organogram comprising various dimensions: economic, social, technical, environmental, and institutional effectiveness. On the top of the hierarchy is the sustainable water security as the main goal. On the middle level are the major dimensions, which influence long-term water security. The lower level consists of core elements that are recognised from scholarly works associated with water stability. This model incorporates principles that reflect the SDGs, particularly by advocating for clean water and sanitation (SDG 6) while also considering the impact of water management on marine and freshwater ecosystems (SDG 14) (United Nations 2015). All five of long-term water security characteristics are relative and dependent on a wide range of variables. These factors, identified from the literature (Sharaunga & Mudhara 2016), have a significant impact on water security. By incorporating these diverse elements and dimensions, the model attempted to furnish a holistic understanding of the interrelated components that guarantee the long-term use and administration of water resources.

Despite the numerous frameworks and models developed for appraising water stability, a generally acknowledged technique has not yet been established. In an attempt, the model, in accordance with the recommendations of Saber et al. (2021), takes into account social, economic, infrastructural, ecological, and institutional dimensions, which are essential in any comprehensive assessment of sustainable water security. It is important to mention that certain elements were excluded from this article because of their inherent complexity. Integrated water resource management (IWRM) approach was adopted to coordinate the administration of natural resources among different fields and interested parties, ensuring long-term water use and allocation (GWP 2000). By integrating IWRM, the article aimed to enhance water security and sustainability through improved efficiency and conservation of water resources.

Overall, the model serves as a descriptive framework that integrates a fundamental set of elements and dimensions sourced from various references to secure an adequate quantity of quality water. It embeds features such as public engagement, repairs and operation, informed decision-making, stakeholder engagement, and the promotion of vegetation and water awareness. By incorporating social, economic, infrastructural, ecological, and institutional dimension, as suggested by Saber et al. (2021), this model offers a comprehensive framework for enhancing and managing water resource sustainably. It provides actionable insights and strategies that stakeholders can utilise to guarantee the long-term availability as well as potable water, thereby enhancing overall water security. In addition, the significance of this framework is highlighted by its flexibility, as it potentially could be extended and adapted to various locations.

Model application

The implementation of the suggested model, as depicted in Figure 3, necessitates a thoroughly inclusive as well as interactive strategy that addresses multiple dimensions and key elements. The model is designed to ensure a thorough understanding of water-related challenges and to foster effective stakeholder engagement. Following is a detailed, step-by-step outline for implementing the model:

The case for an approach to water security

From the foregoing, it is clear that the proposed model has the potential to enhance the consistent provision of water supplies of appropriate standard at the local level. This model can assist communities, relevant participants, public policymakers, leaders, and bureaucrats in prioritising and optimising resource efficiency to ensure that available resources are utilised to foster sustainable livelihoods. Recognising the critical role of water, the model incorporates five dimensions as recommended by Saber et al. (2021). These five dimensions – economic, social, technical, environmental, and institutional effectiveness – are explored in detail in this section:

The economic dimension is a critical aspect of water administration, focusing on ensuring a consistent water provision for essential domains like farming, energy, and manufacturing (Marcal et al. 2021b). This dimension includes various economic factors, such as income levels, stability, decision-making quality and productivity. As Mayunga (2007) notes, addressing water-related challenges necessitates consideration of these economic elements. Maximising water's productive use is crucial, as many economic activities depend on it. Water is vital for agriculture, supporting crop production and livestock, which sustain rural livelihoods and food security (Chamhuri & Ahmed 2014). Furthermore, water is essential for everyday activities such as cooking and cleaning. Ignoring water issues can lead to significant economic repercussions, threatening livelihoods. Countries can achieve sustainable, cost-effective growth and enhance their capacity to tackle water-related challenges by incorporating financial aspects into water administration strategies.

Examining water supply systems through a social lens reveals how administrative decisions affect water use, availability, and demand. Understanding societal norms, traditional practices and typical usage patterns is essential for effective water administration. The social dimension highlights the importance of user engagement, involving a diverse range of stakeholders, including water users and local community members. Lazarus et al. (2017) found that when individuals participate in decisions that impact them, they are more invested in the success of such initiatives and more supportive of sustainable practices. Water education programmes are vital for empowering communities to engage in governance (Dudley et al. 2018). Enhanced education and training equip individuals to better address water-related challenges (Islam et al. 2020). A unified approach can advance SDGs and indicators, reinforcing the need to incorporate social, technological, and ecological aspects into water resource administration for long-term sustainability (Alshehri 2014).

The technical component of water supply system management is crucial for resourceful and long-term delivery. Figure 1 illustrates the complexity of this dimension, which encompasses several key elements essential for effective operation. Climate adaptation is the primary focus of water infrastructure, as climate change positions significant encounters, including rising temperatures and changing precipitation patterns that impact water availability and quality. To enhance resilience, infrastructure must be designed, upgraded, and maintained to withstand these climate effects (Smith et al. 2019). Additionally, improved maintenance and operations are necessary to avert interruptions and water losses that can undermine system efficiency. Ensuring a continuous supply of safe water is also essential for the well-being of the populace and general public health. Alshehri (2014) stresses the importance of integrating these technical considerations into decision-making for water supply systems, advocating for integrated method that addresses climate resilience, effective maintenance, and tailored infrastructure.

The institutional dimension of water resources management is crucial, as it encompasses the rules, regulations, and frameworks that govern interactions among different participants including water sources. This dimension evaluates the agencies, regulatory bodies, and instruments that influence operational decisions in water management. A major concern is the performance of institutional arrangements, as proficient and sound governance is necessary for transparent decision-making, equitable water distribution, and sustainable practices. Collaboration efforts among stakeholders are also essential because they can improve water efficiency, stimulate innovation, and tackle intricate water issues more efficiently (Fisher et al. 2018). Relatively, engaging diverse stakeholders poses encounters and possibilities, as balancing stakeholder priorities necessitates inclusive decision-making approaches. On the contrary, involving stakeholders cultivates a sense of responsibility and can result in more conversant and sustainable management judgements (Hauck et al. 2015).

The last aspect centres around aquatic ecosystems, such as groundwater, wetlands rivers, and lakes, while appraising improvement in reinstating their natural functions (Wilhelm et al. 2022). The environmental dimension includes protecting water supplies, upholding water standard, and protecting the environment. Water stability pertains not only to satisfying humankind requirement but also to ensuring the sustainability of ecosystems. Wastewater discharges are a significant source of water pollution, adversely affecting human health and ecosystems. The release of untreated wastewater has the ability to pollute water sources, diminish

quality, and endanger marine ecosystems (Qadir et al. 2020). Therefore, effective wastewater treatment is crucial for safeguarding water resources and the environment. Protecting ecosystems ensures a continuous supply of safe water and a constant nourishment source for humankind.

This article has significant implications for policymakers, water resource managers, and stakeholders in South Africa. The localised framework for sustainable water security can be adopted as a decision-support tool to guide water management strategies tailored to the specific socio-economic and environmental conditions of individual communities. By focusing on household-level water security, the article addresses pressing social equity issues, ensuring that vulnerable populations in rural and semi-urban areas are not overlooked in national water management plans. This article also highlights the importance of incorporating sustainability indicators into water security frameworks to address the long-term environmental, economic, and social consequences of water scarcity. Future research should aim to test the framework in other regions of South Africa or in countries facing similar water security challenges to assess its adaptability and generalisability. Longitudinal studies could furnish a more inclusive understanding of how water security evolves over time, particularly in response to climate change or infrastructure developments.

Conclusion

Based on fieldwork and review of relevant studies, there is an urgent need for a new water management model in South Africa. A total of 81.8% of participants advocate for innovative frameworks that address local conditions through a multidimensional approach that considers economic, social, technical, environmental, and institutional factors. The article underscores the critical need for localised strategies that not only address immediate water security challenges but also contribute to achieving SDGs, which are essential for ensuring equitable access to water. Regardless of countryside or metropolitan regions, the proposed model offers a practical and implementable strategy for tackling sustainable water security challenges and bolstering resilience in local water supply. By incorporating a set of sustainability indicators and considering the diverse factors identified from literature and supported by fieldwork, this framework provides a structured approach to enhance and manage water resources effectively. Despite the complexity and challenges in achieving sustainable water security, the proposed approach can assist policymakers, stakeholders, and communities in making informed decisions to address water-related challenges and ensure the long-term resilience of water supply systems. Future research could test the framework in various contexts. In addition, longitudinal studies on evolving water security issues can be conducted. Lastly, there may be a need to investigate infrastructure needs to improve water quality and access.

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Competing interests

The authors reported that they received funding from the University of South Africa, which may be affected by the research reported in the enclosed publication. The author has disclosed those interests fully and has implemented an approved plan for managing any potential conflicts arising from their involvement.

Authors' contributions

N.M. and V.G. contributed to conceptualisation and methodology. N.M. carried out data curation and formal analysis. V.G. acted as supervisor and was involved in the writing review and editing process.

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Data availability

The data used in this study were collected through a survey conducted in the Bojanala District, located in the North West province of South Africa. Because of privacy concerns, the dataset is not publicly available. Researchers interested in accessing the data for further studies or collaboration may contact the corresponding author, N.M.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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