IJERLAS
International Journal of Educational Review, Law And Social Sciences

ENHANCING THE RESILIENCE OF RURAL COMMUNITIES TO CLIMATE CHANGE THROUGH COMPREHENSIVE CATCHMENT MANAGEMENT: A CASE STUDY OF GROUNDWATER-DEPENDENT COMMUNITIES IN TWO CATCHMENT AREAS OF SOUTH AFRICA

Joyce Loza[1], Kedibone Chueu[2], Dan'sile Daphney Cindi[3], Nontutuzelo Pearl Gola[4], Betty C Mubangizi[5], Phumza Ntshotsho[6]
[1]Ezemvelo KZN Wildlife
[2,3]Department of Agriculture, Land Reform and Rural Development,
South African National Biodiversity Institute
[4,5]NRF/SARChI Chair in Sustainable Rural Livelihoods, University of KwaZulu-Natal
[6]Council for Scientific and Industrial Research
Correspondence Address: kedibonec@gmail.com, n.gola@sanbi.org.za, Mubangizib@ukzn.ac.za, PNtshotsho@csir.co.za

Abstract

With its significant rural population, South Africa faces pressing water challenges, including shortages, ecological degradation, and pollution. These challenges are particularly problematic in rural areas due to infrastructure deficits, weak municipal finances, and low-density settlement patterns. In this context, springs are a crucial water resource for communities. This paper reports on a study to identify existing governance structures and processes for groundwater management. The study also investigated the vulnerabilities of communities dependent on groundwater for their water supply. It explored rural communities' adaptation strategies to ensure equitable, inclusive, and sustainable groundwater availability and management outcomes. The study focused on the Okhahlamba Local Municipality in KwaZulu-Natal and the Matatiele Local Municipality in the Eastern Cape. A pragmatic paradigm, which incorporates both qualitative and quantitative approaches to yield robust insights, was employed in the research. The study highlighted the role of land practices, invasive alien plant species, and waste disposal practices in determining water quality. The study found that the municipalities in the study area lack adequate spring protection strategies. Traditional leaders were found to play a crucial role in rural landscape governance. Springs hold socio-cultural significance beyond water provision, emphasising the need for holistic approaches to spring protection. Innovative strategies are needed to address the evolving challenges to groundwater supply while ensuring cultural sensitivity, improved governance, and sustainable groundwater management practices. A multifaceted approach is recommended to enhance groundwater management and spring protection in rural areas, such as integrating spring protection plans into municipal Integrated Development Plans (IDPs). It is vital that continuous coordination and collaboration with all stakeholders, including traditional leaders and NGOs, be established to accommodate the cultural dimensions of community use of local springs.

Keywords: ***groundwater governance; spring protection; collaborative management; community participation; climate change***

1. INTRODUCTION

Global context of climate change and water security/inequality

Climate change poses a significant global threat, with its most severe consequences expected to impact vulnerable populations disproportionately (Byers et al., 2018). One area that is particularly affected by climate change is water security, making it a central topic in discussions on climate change. In South Africa, impoverished rural communities are especially vulnerable to the detrimental effects of climate change, as ecological systems are becoming less resilient due to widespread loss of biodiversity and ecological degradation (Sintayehu, 2018). Rural municipalities struggle to provide essential services due to limited resources. The COVID-19 pandemic highlighted the disparities in resource access and functioning infrastructure, particularly concerning

clean water availability (Enqvist & van Oyen, 2023). According to South Africa's National Water and Sanitation Master Plan (Department of Water and Sanitation, 2018), the country's significant water challenges are the result of multiple interconnected factors. These include ageing and neglected water infrastructure, cyclical droughts worsened by climate change, and insufficient water supply. Access to clean water and sanitation services is unequal, leaving many people vulnerable. Water quality is declining and there is a shortage of skilled professionals, exacerbating the challenges faced by the country. These challenges negatively impact the economic prosperity and overall welfare of the South African population. Key sectors like agriculture, energy, mining, tourism, and urban and rural development rely heavily on a dependable water supply, which is crucial to South Africa achieving the targets set in the National Development Plan: Vision for 2030 (National Planning Commission, 2011). Over 98% of reliable surface water is already allocated; in most catchments, demand exceeds supply. The Department of Water and Sanitation (2018) has warned that if the current water challenges are not addressed, the country may face a water supply deficit of 17% by 2030.

In general, freshwater ecosystems are crucial to essential services such as water provisioning, purification, flow regulation, flood control, and waste transport. However, as surface water resources reach their maximum utilisation, it is unclear whether naturally functioning ecosystems can continue to deliver adequate water supply services (Apostolaki et al., 2019). Recognising and investing in ecological infrastructure is thus vital to ensure the quality and sufficiency of water supply. Critical components of ecological infrastructure, such as rivers, wetlands, and mountain catchments, are essential for water security and complement bulk infrastructure, such as dams and pipes, used for water storage and distribution (Barreteau et al., 2016). Well-managed ecological infrastructure related to water enhances the quantity and quality of water supply and contributes significantly to a country's development goals and rural economies (ILO, 2019; Everard, 2019). A catchment-based approach is thus widely recognised as an appropriate method for integrated water resource management (IWRM) (Kumar et al., 2019). This approach considers catchments as integrated socio-ecological systems addressing water security challenges. It links ecosystems to people's livelihoods and well-being, involves stakeholders, and considers societal demands and pressures on natural resources. Such a collaborative approach is crucial to effectively adapting to climate change (Everard, 2019). Groundwater is highly susceptible to the impacts of climate change, which can cause significant changes in hydrological systems and the water cycle. These changes often lead to reduced groundwater recharge and increased water demand (Plan et al., 2013). Additionally, non-climatic factors such as population growth, land use changes, agriculture, and human food requirements can influence groundwater (Taghilou, 2022). Therefore, given the risks posed by climatic and non-climatic factors, effective groundwater management is crucial.

Delimiting the construct of groundwater governance.

Groundwater governance is the exercise of appropriate authority to foster responsible collective actions for sustainable and efficient utilisation and protection of resources in the interest of humanity and dependent ecosystems (Foster et al., 2013). Groundwater governance encompasses the political, social, economic and administrative systems that explicitly aim to develop and manage groundwater across different societal levels that heavily rely on groundwater. This includes all mechanisms related to financing, knowledge, technical capacity and the rights and responsibilities of water users and stakeholders (Plan et al., 2013; Jakeman et al., 2016). Furthermore, effective water governance also hinges on a well-informed, robust, and diverse civil society. Groundwater management benefits from a collaborative approach where both government entities and local communities play crucial roles. Community engagement ensures that local knowledge and priorities are considered in decision-making processes, promoting ownership and sustainability of groundwater resources. Simultaneously, government involvement provides the necessary regulatory framework and oversight to ensure the responsible and equitable management

of groundwater. By combining the strengths of both approaches, groundwater management can be more effective and responsive to the needs of both communities and broader societal interests. Blomquist (1985) and Ostrom (1990) highlight two fundamental challenges that arise in groundwater governance: first, groundwater is not confined to a single piece of land; second, it constitutes an invisible, shared subsoil resource. These complexities underscore the importance of instituting rules, norms, and values to guide groundwater governance, further requiring a balanced approach that integrates development and ecosystem considerations (Jakeman et al. 2016).

Groundwater management in South Africa

In many rural South African communities, springs serve as crucial water sources. Unlike surface water bodies, springs are groundwater discharge points where water naturally emerges from the earth's surface. The National Water Act of 1998 (Act 36 of 1998) recognises the significance of groundwater across South Africa. Groundwater, including springs, has become the primary source of domestic water and a lifeline for over 50% of communities residing in villages and small towns, thus playing a crucial role in achieving the national objective of fulfilling basic water needs (Department of Water and Sanitation, 2016). However, despite comprehensive legal frameworks governing resource management in South Africa, there are notable deficiencies in current groundwater governance and management policies and their implementation (Department of Water and Sanitation, 2018). Groundwater management, especially in rural areas, is beleaguered by under-capacitation compared to surface water management, potentially hindering the effective management of groundwater resources such as springs (Knüppe, 2011; Cox et al., 2015). In the absence of reticulated water, springs remain crucial for rural households, emphasising the need for clear guidelines and institutionalisation of groundwater-related initiatives in municipal IDPs (Knüppe, 2011; Tapela, 2015). Building capacity and knowledge within local government and communities is essential to ensure sustainable management of springs and other groundwater sources.

Scope and purpose of the study

This study aimed to understand communities' vulnerabilities and adaptive capacity in relation to their dependence on springs within the uThukela and uMzimvubu catchments. An in-depth examination was conducted of the roles played by various stakeholders and the perspectives of members of the community regarding the protection of springs. The study critically evaluated the extent to which groundwater management was integrated into municipal plans.

2. IMPLEMENTATION METHOD

The research methodology employed in this study adhered to a pragmatic paradigm, embracing a mixed-methods approach to facilitate the generation and analysis of a comprehensive dataset comprising both qualitative and quantitative components (Kaushik & Walsh, 2019). A combination of questionnaires, interviews, focus groups, feedback from key stakeholders, and a hydrocensus databases were utilised to gather data. During stakeholder engagement sessions, a stakeholder mapping exercise was conducted to visually represent the various stakeholders involved in spring management and understand their respective interests and influence. This exercise aimed to identify and categorise stakeholders based on their roles and relationships in the management of springs.

Data on socio-cultural behaviours and beliefs were collected during interactive group sessions conducted during workshops and spring site visits. Traditional leaders, who provided culturally sensitive insights with respect to local traditions and customs, were among the participants. Other community members with a stake in the protection of groundwater resources also contributed to the discussions. Participants' identities were protected during data collection to ensure confidentiality and ethical standards. Geospatial data were extracted from hydrocensus databases from non-governmental organisations (NGOs) and municipalities to provide comprehensive information on water features, potential sources of water pollution, spring location, type, condition, and the number of individuals depending on the spring. For the uMzimvubu River catchment in the Eastern Cape, geospatial data were sourced from Environmental Rural Solutions

(ERS), the World Wide Fund for Nature South Africa (WWF-SA), Lima Rural Development Foundation (LIMA), and Conservation South Africa (CSA). Citizen science tools and ground-truthing exercises were utilised to map identified springs in the Sibi area. In the Thukela River catchment in KwaZulu-Natal, hydrocensus datasets were sourced from Okhahlamba Local Municipality and uThukela District Municipality. The hydrocensus dataset was processed to clean and standardise attribute information using Geographic Information System (GIS) software. The spatial representation of attributes per spring was then visualised on maps. Municipal Integrated Development Plans (IDPs) and national census data were also utilised to examine socio-cultural dynamics within the local municipalities, providing additional context for the study.

3. RESULTS AND DISCUSSION

The exploration of vulnerabilities and adaptive capacities within the uThukela and uMzimvubu catchments unfolds through several thematic areas, discussed in the sections that follow. These themes reveal distinct, yet interconnected, aspects of groundwater governance, community engagement, and socio-cultural practices, shedding light on the multifaceted dynamics shaping water management in the regions under study.

1. Identification of Existing Networks and Engagement: This section elucidates the intricate web of networks and stakeholder engagements that underpin groundwater management efforts within the catchments. We aim to provide insights into the structures and processes that facilitate collective action and knowledge exchange by mapping out existing collaborations and community partnerships.
2. Adaptive Capacity Vulnerabilities within the Two Catchments: Here, we delve into the vulnerabilities inherent in the socio-economic and environmental fabric of the uThukela and uMzimvubu catchments. By analysing socio-economic indicators, environmental stressors, and community resilience factors, we identify key areas of vulnerability and potential avenues for adaptive capacity building.
3. Groundwater Governance in the Two Catchments: This section scrutinises the governance frameworks and institutional arrangements governing groundwater resources. By examining policy instruments, regulatory mechanisms, and stakeholder roles, we aim to assess the effectiveness and inclusivity of groundwater governance structures and identify areas for improvement.
4. Cultural Beliefs and Practices in Groundwater Management: This section explores the cultural beliefs, traditions, and practices that influence community perceptions and behaviors towards water resources. By understanding the interplay between cultural norms and water management practices, we aim to elucidate opportunities for integrating traditional knowledge with modern approaches to water governance.
5. Vulnerabilities in the uThukela and uMzimvubu Catchments: Finally, we synthesise the findings from the preceding sections to provide a comprehensive overview of the vulnerabilities facing the uThukela and uMzimvubu catchments. By contextualising the interconnected themes of community engagement, adaptive capacity, governance, and socio-cultural dynamics, we aim to offer nuanced insights into the challenges and opportunities for sustainable groundwater management in these regions.

Identification Of Existing Institutional Networks And Engagement

Table 1 presents a stakeholder analysis for spring protection in the uMzimvubu catchment area. Stakeholders are listed in the first column, including traditional leaders, environmental non-governmental organisations (NGOs), government agencies, farmers associations, water users' groups, and academic institutions. The interest level of each stakeholder in spring protection is rated on a scale from 1 to 5, where 1 represents minimal interest, and 5 illustrates strong interest. The i level of each stakeholder's influence on spring protection is rated using the same scale. This

analysis helps to identify key stakeholders and their potential roles in efforts to protect springs within the uMzimvubu catchment area.

Table 1 Levels of influence and interest of stakeholders in the uMzimvubu catchment with regard to spring protection

Stakeholder	Influence*	Interest*
Matatiele Local Municipality (MLM)	3	5
Department of Water and Sanitation (DWS)	3	5
Alfred Nzo District Municipality (ANDM)	5	5
Maloti Drakensberg Transfrontier Project (MDTP)	5	5
World Wildlife Fund – SA (WWF)	5	5
Eastern Cape Department of Economic Development Environmental Affairs and Tourism (EC DEDEAT)	3	5
The Department of Forestry, Fisheries and the Environment (DFFE - Working on Fire programme))	4	1
Department of Forestry Fisheries and Environment (DFFE)	3	5
Department of Cooperative Governance and Traditional Affairs (COGTA)	5	1
Department of Agriculture, Land Reform and Rural Development (DALRRD)	5	5
South Africa National Biodiversity Institute (SANBI)	5	5
Sibi (traditional authority)	5	5
Council for Scientific and Industrial Research (CSIR)	1	5
Conservation South Africa (CSA)	5	5
University of KwaZulu-Natal	5	5
Eastern Cape Parks and Tourism Agency (ECPTA)	1	5
Eastern Cape Department of Rural Development and Agrarian Reform (DRDAR)	5	5
LIMA Rural Development	4	5
Rhodes University	3	5
Mehloding Community Trust	1	1
Environmental and Rural Solutions (ERS)	5	5
Congress of Traditional Leaders of South Africa – Eastern Cape (CONTRALESA)	5	5

*Scale range is 1 to 5, where 1 signifies minimal influence or interest and 5 signifies strong influence or interest.

Stakeholders such as Alfred Nzo District Municipality (ANDM), Ezemvelo KZN Wildlife (Maloti Drakensberg Transfrontier Project), World Wildlife Fund – SA (WWF), Department of Agriculture, Land Reform and Rural Development (DALRRD), Sibi (traditional authority, Conservation South Africa (CSA), University of KwaZulu-Natal, Eastern Cape Department of Rural Development and Agrarian Reform (DRDAR), Environmental and Rural Solutions (ERS), and Congress of Traditional Leaders of South Africa – Eastern Cape (CONTRALESA) demonstrated high levels of both influence and interest (rated 5 out of 5) in the matter. These stakeholders played significant roles and were deeply engaged in the relevant activities or initiatives. Other stakeholders, including Matatiele Local Municipality (MLM), Department of Water and Sanitation (DWS), Eastern Cape Department of Economic Development Environmental Affairs and Tourism (EC DEDEAT), and Department of Forestry Fisheries and Environment (DFFE), showed moderate levels of influence (rated 3) but high interest (rated 5). This indicates their active engagement and interest despite relatively lower levels of influence. Some stakeholders, such as DFFE (Working on Fire), Department of Cooperative Governance and Traditional Affairs (COGTA), Council for Scientific and Industrial Research (CSIR), Eastern Cape Parks and Tourism Agency (ECPTA), and Rhodes University, exhibited varying levels of influence

and interest. For instance, some had higher influence but lower interest (rated 1 for interest), or vice versa, suggesting different degrees of engagement and potential roles in decision-making processes related to the issue. Additionally, stakeholders like Mehloding Community Trust showed minimal influence and interest (rated 1 for both), indicating their limited involvement or engagement in the matter. Table 2 presents a stakeholder analysis for spring protection in the uThukela catchment area.

Table 2 Levels of influence and interest of stakeholders in the uThukela catchment with regard to spring protection

Stakeholder	Influence*	Interest*
Department of Forestry, Fisheries and Environment (DFFE)	5	5
Maloti-Drakensberg Transfrontier Conservation and Development Project (MDTDP)	5	5
KZN Economic Development, Tourism & Environmental Affairs (KZN EDTEA)	5	5
Department of Water and Sanitation (DWS)	5	5
AmaZizi (traditional authority)	5	5
Okhahlamba Local Municipality (OLM)	5	5
AmaNgwane (traditional authority)	5	5
Uthukela District Municipality (UDM)	5	5
AmaSwazi (traditional authority)	5	5
Wildlands Conservation Trust	5	5
The Department of Forestry, Fisheries and the Environment (DFFE - Working on Fire programme)	4	1
Department of Cooperative Governance and Traditional Affairs (COGTA)	5	1
World Wildlife Fund – SA (WWF)	4	5
KZN Department of Agriculture and Rural Development	5	1
Institute of Natural Resources (INR)	5	5
AmaNgwane (traditional authority) Project Steering Committee	1	5
Council for Scientific and Industrial Research (CSIR)	5	5
AmaSwazi (traditional authority) Project Steering Committee	1	5
Department of Agriculture, Land Reform and Rural Development (DALRRD)	5	5
Project Steering Committee (AmaZizi)	1	5
AmaZizi Concerned Citizens	1	5
South Africa National Biodiversity Institute (SANBI)	5	5

* Scale range is 1 to 5, where 1 signifies minimal influence or interest and 5 signifies strong influence or interest.

The majority of stakeholders, including governmental departments such as the Department of Forestry, Fisheries and Environment (DFFE), Ezemvelo KZN Wildlife, KZN Economic Development, Tourism & Environmental Affairs (KZN EDTEA), Department of Water and Sanitation (DWS), as well as traditional authorities such as AmaZizi, AmaNgwane, and AmaSwazi, exhibited high levels of both influence and interest (rated 5 out of 5) in the matter of spring protection. This indicates their significant role and keen engagement in the relevant activities or initiatives. Other organizations, like the Okhahlamba Local Municipality (OLM), Wildlands Conservation Trust, Institute of Natural Resources (INR), Council for Scientific and Industrial Research (CSIR), and Department of Agriculture, Land Reform and Rural Development (DALRRD), also demonstrated strong influence and interest in the issue, suggesting their active involvement and commitment to the cause.

A few stakeholders varied in their levels of influence and interest. For instance, stakeholders like DFFE (Working on Fire), World Wildlife Fund – SA (WWF), KZN Department of Agriculture and Rural Development, and South Africa National Biodiversity Institute (SANBI) displayed high influence but lower interest (rated 4 or 5 for influence but 1 for interest). Conversely, stakeholders like the Project Steering Committees for AmaNgwane, AmaSwazi, and AmaZizi, as well as AmaZizi Concerned Citizens, exhibited high interest but lower influence (rated 5 for interest but 1 for influence). These differences suggest varying degrees of engagement and potential roles in decision-making processes related to spring protection. Overall, the findings highlight the diverse landscape of stakeholders involved in spring protection, with differing levels of influence and interest, which could inform strategies for collaboration, engagement, and decision-making moving forward.

Adaptive capacity vulnerabilities within the two catchments

The vulnerabilities of the two catchments, particularly as they rely heavily on groundwater, are a significant concern. The lack of sufficient water infrastructure exacerbated the challenges faced by these communities. This issue was particularly acute in the rural areas located on the outskirts of administrative boundaries, with Matatiele and Okhahlamba Local Municipalities serving as illustrative case studies. Rural communities in these regions depend heavily on natural resources for essential services, primarily utilising springs as their main water source for various needs, including drinking, sanitation, livestock, household requirements, and cultural practices.

Table 3 presents an assessment of vulnerabilities impacting the adaptive capacity of communities dependent on groundwater in the uThukela and uMzimvubu river catchments. The vulnerabilities are classified into different processes and categorized based on their perceived risk levels: high risk, medium risk, and low risk. The data for this table were collected from 82 respondents in the catchment areas through an online survey, following the methodology outlined by Peterson et al. (2012).

The vulnerabilities are grouped into three main classifications:

1. Direct climate-induced changes and sedimentations of springs: This category includes vulnerabilities directly linked to climate change and sedimentation of springs. The high-risk factors identified include desiccation caused by prolonged drought and siltation resulting from excessive rainfall. Medium-risk factors include unsuitable land use near spring sources.
2. Indirect climate-induced changes and pollution: This category encompasses vulnerabilities arising from indirect impacts of climate change and pollution. High-risk factors in this classification include pollution from leached fertilizers, household waste, and human waste, as well as invasion of alien plants and reduced ground cover due to wildfires. Additionally, animal activities contribute to medium-risk pollution.
3. Limited awareness: This category focuses on vulnerabilities stemming from a lack of awareness within the community, local governing bodies (municipalities), and civic institutions, including traditional leadership. All aspects of limited awareness are perceived as high risk, indicating a significant need for education and awareness-raising efforts.
4.

Table 3 Classifications of vulnerabilities impacting adaptive capacity in the uThukela and uMzimvubu river catchments

Classification	Process	High risk	Medium risk	Low risk
Direct climate-induced changes and sedimentations of springs	Drying up caused by prolonged drought			X
	Siltation resulting from excessive rainfall	X		
	Unsuitable land use near spring source		X	
Indirect climate-induced changes and	Pollution through animal activities			X
	Pollution from leached fertilisers	X		

Classification	Process	High risk	Medium risk	Low risk
pollution	Pollution from household waste		X	
	Pollution from human waste		X	
	Invasion of alien plants			X
	Reduced ground cover due to wildfires		X	
Limited awareness	Within the community	X		
	Among local governing bodies (municipality)		X	
	Within civic institutions, including traditional leadership		X	

Results of the survey for each of the three categories identified in Table 3 are discussed next.

Direct climate-induced changes and sedimentation of springs as a source of spring vulnerability.

Figure 3 illustrates the stakeholder assessment of risk associated with direct climate-related vulnerabilities of springs. It visually represents the percentages of respondents who considered each vulnerability as posing a significant risk, providing insights into the perceived importance of different factors in contributing to spring vulnerability. The study found that direct climate-induced changes and sedimentation of springs are significant sources of vulnerability for spring systems. Analysis of stakeholder responses (Figure 3) revealed that a higher percentage of respondents (37%) identified silting caused by excessive rainfall as a significant risk factor compared to other direct climate-related vulnerabilities. This was followed by concerns about springs drying up due to severe drought (28%) and inappropriate land use around the spring's mouth or eye (18%). Most respondents rated improper land use around the spring's mouth as a medium-risk factor.

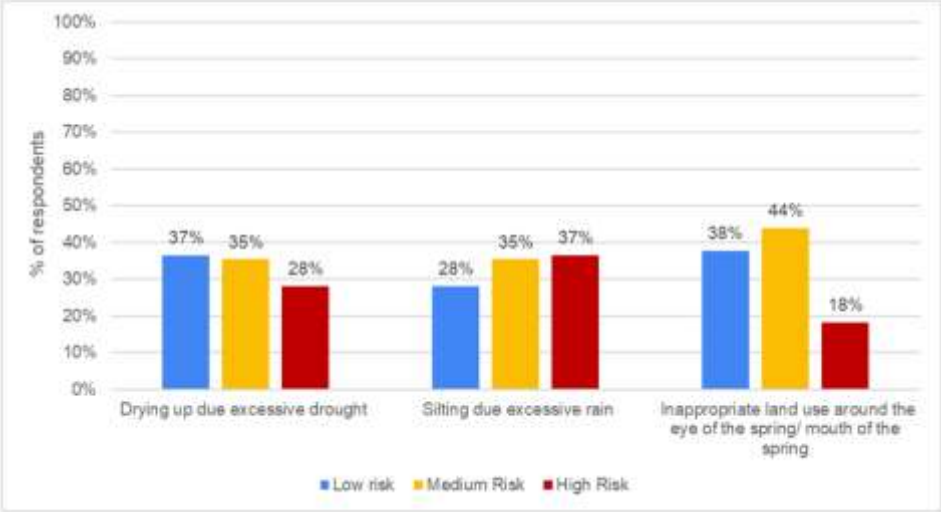

Figure 3 Stakeholder assessment of risk associated with direct climate-related vulnerabilities of springs

Indirect climate-induced changes and pollution as a source of spring vulnerability.

Figure 4 presents stakeholders' assessments of risk factors indirectly influenced by climate change. It visually represents the percentages of respondents who identified each risk factor as posing a significant risk, providing insights into the perceived importance of different factors contributing to spring vulnerability.

The study investigated indirect climate-induced changes and pollution as significant sources of vulnerability for springs. Findings revealed that approximately half of the respondents (52%) considered animals to be a high-risk source of contamination compared to other potential sources. Contamination from human excrement and household refuse was perceived as a medium risk by 45% and 43% of respondents, respectively, highlighting concerns about water pollution and its associated health risks. Additionally, 38% of respondents expressed concern about the depletion or loss of ground cover through wildfires, viewing this as a medium-risk issue. Interestingly, alien invasive plants were perceived as the least risky point of contamination. This suggests that stakeholders may prioritize other sources of pollution over the presence of invasive plant species. These findings underscore the diverse range of concerns and perceptions regarding indirect climate-induced changes and pollution among stakeholders in the study areas.

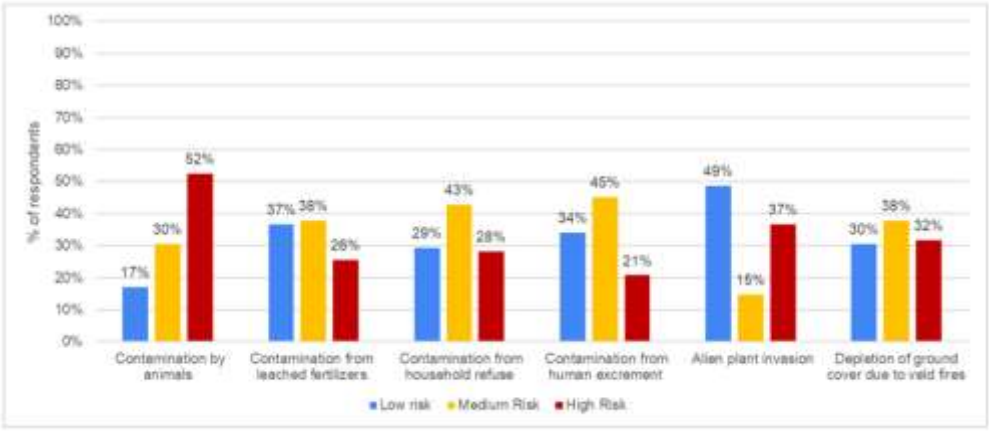

Figure 4 Stakeholders' assessment of risk factors indirectly influenced by climate change

Limited awareness as a source of spring vulnerability.

Figure 5 depicts survey participants' awareness of the significance of groundwater, highlighting the disparities in awareness levels between the community and local governing bodies. This lack of awareness among community members presents a significant risk to groundwater management and underscores the need for targeted education and outreach initiatives to enhance community understanding and engagement regarding groundwater resources.

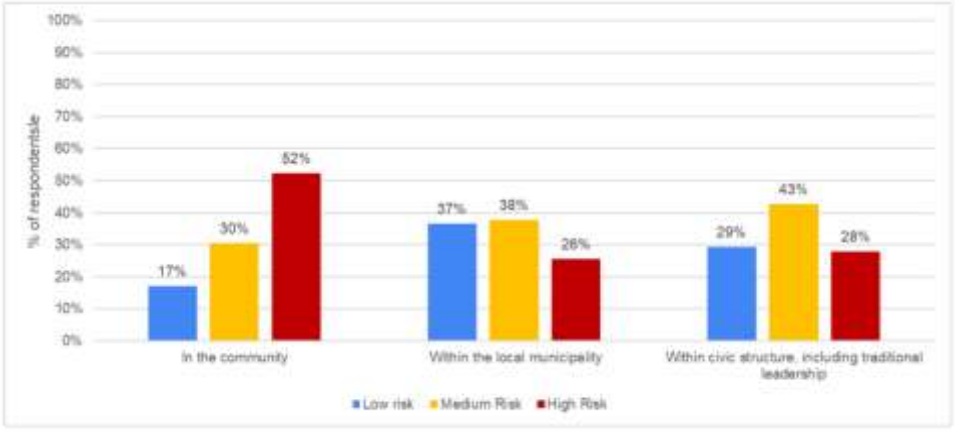

Figure 5 Assessment of participants' awareness of significance of groundwater

The study emphasised the critical importance of raising awareness about groundwater among communities to strengthen their adaptive capacity. Recognizing groundwater as a valuable communal asset and understanding its dependency on various factors for sustainability are essential components of this awareness. However, findings revealed a notable lack of awareness within the community residing near the springs, contrasting with the awareness levels observed in the local municipality and civic structures.

Spring protection through collaborative governance in uMzimvubu and uThukela catchments

Public participation in groundwater governance involves establishing a structured framework that delineates the rights and obligations of groundwater users (Jakeman et al., 2016). This study investigates the presence of explicit norms, guidelines, and processes governing groundwater use and springs management. Findings reveal a consensus among respondents that explicit norms and guidelines are lacking to steer communities and relevant institutions in spring management. Despite the absence of formal frameworks, communities, often collaborating with NGOs, have taken on the primary responsibility for protecting springs, albeit informally and sporadically. Despite the crucial link between spring protection and water quality, communities exhibit limited awareness and intrinsic willingness to safeguard springs.

At the municipal level, efforts to address spring protection were evident in the Integrated Development Plan (IDP) of the uThukela District Municipality. However, the Alfred Nzo District Municipality lacked a groundwater management plan, and its IDP did not address spring protection. At the time of the study, only 38% of springs in the uMzimvubu catchment and a mere 6% in the Thukela catchments benefitted from protection measures. The higher level of protection observed in the uMzimvubu catchment can be attributed to the collaborative efforts of NGOs, traditional authorities, and local communities. Conversely, in the uThukela catchment, reliance on the district municipality for spring protection was notable. The uThukela District Municipality had taken steps to integrate spring protection into its plans, offering the promise of a more sustainable approach. However, in Umzimvubu, the reliance on sporadic NGO funding suggests that the efforts may not be sustainable in the long run. Ideally, collaboration between NGOs, communities, and municipalities is necessary for sustained protection, focusing on integrating spring protection into municipal plans.

Stakeholder discussions underscored the urgent need for the community as a whole to understand the threats posed to springs in order to motivate behavioural changes that would reduce pollution, as well as the importance of community-based structures for groundwater management and spring safeguarding. Local government plays a crucial role in catchment management, especially in spring preservation. Participants emphasised the necessity of engaging political leaders due to their authority over financial allocations. While acknowledging resource constraints, they envisioned local government serving as a catalyst for developing sustainable groundwater management practices, with support from other sectors through intergovernmental collaboration. Participants stressed the importance of involving affected communities in participatory discussions concerning spring protection. Stakeholder workshops identified natural resource management as a critical driver affecting water security and the quality and quantity of water from springs in both catchments. Community perceptions pinpointed invasive alien plants, inadequate grazing practices, and improper waste disposal around springs as critical issues requiring urgent attention. Scott and Le Maître's (1998) recommendations for developing guidelines and expert systems to assess groundwater-vegetation interactions and vulnerability remain relevant. Harmonisation of policies and strategies addressing water and land management at the community level is needed. Despite the greater prevalence of spring protection in the uMzimvubu catchment, most respondents expressed dissatisfaction with water quality, as indicated in Figure 6. Conversely, in the uThukela catchment, the majority rated the water quality as average.

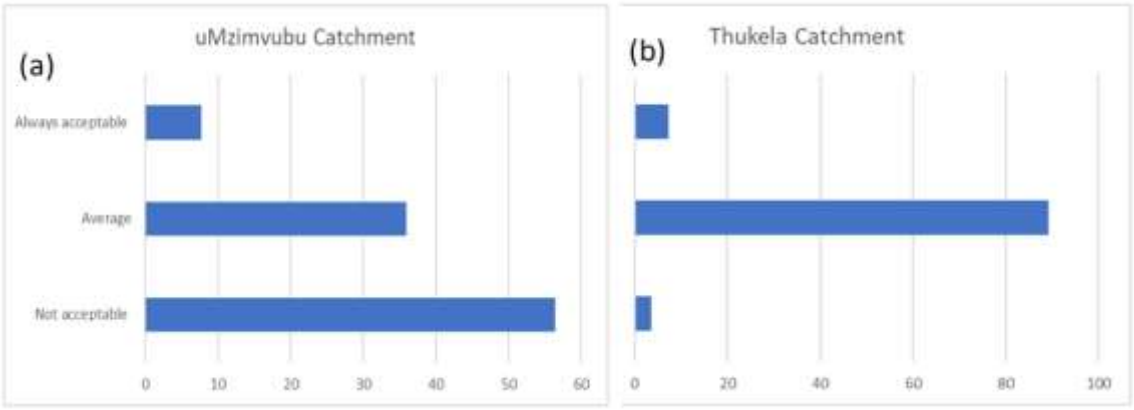

Figure 6: Respondents' perception of the quality of spring water in uMzimvubu and uThukela catchments

Groundwater governance in the two catchments

Understanding the governance provisions detailed in municipal plans is crucial for developing effective adaptive capacity strategies for climate change and holistic catchment management to support groundwater-dependent communities. Strengthening governance and institutional frameworks for groundwater resource management is vital in this regard. The subsequent findings are derived from the two districts' Integrated Development Plans (IDPs). The 2020/2021 IDP of the uThukela District Municipality indicated a substantial commitment to groundwater protection as part of its role as a Water Services Authority (Acts 108, 1997). The IDP prioritised spring protection and upgrades, with a dedicated plan for 2020/2021 to safeguard 42 springs and bolster water storage. The IDP acknowledged the long-term threats posed to water security, including grassland degradation. These were addressed through interventions such as recycling, awareness campaigns, pollution control initiatives, education, and rehabilitation of dongas through cutting, plugging and planting vegetation (uThukela District Municipality, 2020/2021).

The 2017-2018 Integrated Development Plan for Alfred Nzo District Municipality indicated that it served as both the Water Service Authority (WSA) and Water Service Provider (WSP) for the uMzimvubu catchment. The plan indicates the municipality was focused primarily on water supply projects, with approximately R14.6 billion allocated to address backlogs with standalone schemes using streams, springs, and boreholes for rural communities. Despite its significant responsibilities with regard to water resources, the 2017-2018 IDP did not included a dedicated groundwater management plan; the plan cited the costs of groundwater treatment to meet required standards as the reason (Alfred Nzo District Municipality, 2017-2018). Although the IDP did not explicitly address spring protection, the municipality planned to participate in various interventions related to the catchment. The District Environmental Forum (DEF) established under the National Environmental Management Act, convenes quarterly and involves representatives from government sectors, local municipalities, and civil society. The uMzimvubu Catchment Partnership (UCP), a non-statutory platform, engages stakeholders in catchment management discussions.

Vulnerabilities affecting the water flow of springs

The first vulnerability identified was dwindling water flow. Climate change has caused elevated temperatures and increased rainfall variability, resulting in frequent, short-lived, low rainfall in specific areas of the catchments. Erratic rainfall patterns, worsened by rising temperatures, have led to frequent droughts and reduced groundwater recharge (DWS, 2016). Consequently, spring water quantity has decreased, and some springs have dried up in certain regions.

The second vulnerability was the lack of spring protection, which is often overlooked. The absence of proper security has led to the contamination of some springs through humans and livestock use. Traditional authorities usually initiate spring protection initiatives, which are then communicated to the municipality. However, the issues addressed and proposed reforms had not found their way into the municipal Integrated Development Plans (IDPs). To address this, community members identified the need for more vital collaboration between traditional authorities, municipalities, and local NGOs. They believed effective spring protection measures should be implemented, along with using existing regulatory instruments such as the Veld Sanitation Guide and Spring Protection Guide and Toolkit. Moreover, there is a noticeable deficiency in information and data management regarding springs. While some information exists, participants expressed a desire for improved organization and accessibility. They also highlighted the necessity for support from research institutions to facilitate the collection and dissemination of information effectively. Furthermore, communities possess a deep understanding of the social and cultural significance attached to springs, which are governed by specific usage rules. These rules distinguish between springs designated for general use, which can be protected by structures, and those reserved for traditional healers, which are to remain untouched. There is a prevalent belief that altering springs designated for traditional healing purposes with built structures renders them impure.

DISCUSSION

The findings uncover deficiencies in policy concerning groundwater governance and its practical implementation. This echoes Mechlem's (2016) investigation, which highlighted the neglect of groundwater across various regions, including South Africa. Fragmented legislative strategies, inadequate institutional structures, poor enforcement of groundwater regulations, and limited inclusion of groundwater management in municipal plans were evident in this study. Consequently, many communities find themselves vulnerable, particularly in the face of climate change. Enhancing institutional frameworks and governance is imperative to bolster communities' resilience to changing conditions (Jakeman et al., 2016). There is a pressing need to strengthen the effectiveness of existing governance provisions and enhance the capacity for robust groundwater governance implementation. The evidence of ineffective groundwater governance in this study aligns with Knüppe's (2011) findings, which underscored a widespread lack of technical and professional competence at the local level, resulting in an uncoordinated approach to groundwater management in the two catchments.

Engaging local stakeholders and leveraging their knowledge is essential for crafting sustainable solutions. Recognising the complexities of rural water governance is crucial to guiding the collaborative development of strategies to enhance rural communities' adaptive capacity to navigate climate alterations (Plan et al., 2013). In the uThukela and uMzimvubu catchments, communities recognised the importance of safeguarding springs and constructing protective structures around the spring eye. They considered these springs as their primary source of drinking water. However, they were mindful that some individuals use springs for spiritual and religious practices. Rooted in African spirituality, the belief persists that each natural resource, including springs, possesses a guardian and that the spring eye, which is viewed as the source, holds a unique healing power. Consequently, communities indicated that they expect developers to seek prior consent before modifying or protecting springs and are reluctant to protect a spring eye with elaborate structures, as this could disrupt the natural flow of the spring, impeding its ability to breathe, as intended by nature.

Recommended strategies for strengthening groundwater governance for resilient communities

The Department of Water and Sanitation has developed a comprehensive National Groundwater Strategy which serves as a solid basis for enhancing the ability of rural communities

in areas dependent on groundwater to adapt to climate change (DWS, 2016). By actively involving stakeholders and leveraging existing knowledge, the following innovative strategies can be developed to address the challenges that have been identified. Promote collaborative governance. This research highlights diverse stakeholders' unique abilities and skills, emphasising that collaborative efforts and partnership structures significantly improve groundwater governance and management. This also aligns with the need for a pluralism that embraces a network governance approach (Varady et al., 2012). By combining the hierarchical governance style of the government with the informal network governance style of catchment partnerships such as the UCP, local communities can be encouraged to participate in decision-making processes regarding groundwater security.

Enhance municipal involvement with community input. Striking a balance between bottom-up and top-down approaches is crucial. It is essential to make a concerted effort to involve municipalities more extensively while ensuring that the voices of the community are heard in matters related to water security and supply. Active participation from stakeholders, including communities dependent on groundwater, is essential to co-creating and co-developing strategies to enhance adaptive capacity (Varady et al., 2012). Implementing a catchment-wide approach to clearing invasive alien plants and managing grazing will yield better outcomes. Collaborating with municipalities and rural households is crucial for adopting innovative waste management practices. The voices of the community, especially women as primary beneficiaries, should be considered. Additionally, ongoing engagement and support from civil society organisations should be encouraged. The importance of indigenous knowledge must also be recognised. Recognise traditional leadership. Given the communal and traditional land ownership systems in place at the study sites, the role of traditional leaders in groundwater governance should not be underestimated. Cox et al. (2015) argue that traditional leaders oversee resource and land use within their traditional territories, guided by customary norms. In this study, it was found that these norms often clash with the objectives, authorities, and goals of other administrative levels, however. Promoting the integration of indigenous knowledge into catchment management can deepen the understanding of the socio-cultural benefits springs provide as crucial ecological infrastructure.

Enhance groundwater governance. The development of integrated groundwater management plans is of paramount importance to regions heavily reliant on groundwater. These plans should encompass both built infrastructure, such as boreholes, and ecological infrastructure, such as springs, to effectively address the diverse needs and specific circumstances of each community. Build capacity and raise awareness. Engaging various stakeholders—including traditional leaders, civil society organisations, community structures, schools, and local government—is crucial for generating awareness and enhancing capacity in groundwater management. Additionally, incorporating citizen science tools into the monitoring of springs while considering cultural and spiritual aspects is essential. Promote exchange of knowledge. Enabling knowledge exchange between stakeholders and partners in groundwater governance in the uThukela and uMzimvubu catchments can facilitate the sharing of best practices, insights, and experiences in groundwater and spring management.

4. CONCLUSION

This study highlights the need for improved natural resource management in South Africa, particularly in spring protection. Despite the existing legal provisions, adequate institutional frameworks and operational capacity for effective implementation are lacking. The research suggests that collaborative governance involving government institutions, communities, and traditional leaders is essential to enhance accountability, coordination, and the sustainability of spring management. This approach should be tailored to community needs and involve knowledge co-production and innovation among diverse stakeholders. The study stresses the importance of understanding the network of stakeholders in groundwater management and the necessity of stakeholder mapping—including stakeholders in the local community—to clarify roles and responsibilities with regard to water security decisions. The study highlights the need for municipalities to formalise spring protection into their Development Plans (IDPs). At the time of

the study, the IDPs of the two municipalities lacked clarity on infrastructure development, monitoring or maintenance of springs. It is vital that the communities in which springs are located are engaged in the process of developing norms and guidelines to ensure that socio-cultural beliefs and practices are considered. The study stresses the role of traditional leaders in spring quality monitoring. Communities should be informed by NGOs and municipalities about groundwater characteristics and encouraged to act responsibly. Additionally, NGOs and municipalities working on spring protection should respect the spiritual and cultural significance of springs.

Collaboration between municipalities, NGOs, traditional authorities and policymakers is crucial for prioritising and implementing groundwater projects. This research found that springs are a critical water source for many rural households, but there is a lack of consistency in integrating spring protection across municipalities. Therefore, strengthening groundwater governance requires building institutional capacity, promoting stakeholder collaboration, integrating spring protection into municipal planning, and recognising cultural and spiritual values. The paper highlights the need for municipalities to focus on technical support, skills training, community involvement, and capacity building in groundwater-related projects. Further research is recommended to understand various aspects related to spring use and protection, including groundwater dependence, water quality testing, the role of African spirituality, and environmentally friendly rural waste management practices.This study contributed to an understanding of communities' vulnerabilities and adaptive capacity, which is hoped will contribute to long-term water security in the region

REFERENCES

Alfred Nzo District Municipality (ANDM). (2017-2018). Alfred Nzo District Municipality Integrated Development Plan 2017-2022. Retrieved online: https://www.andm.gov.za/wp-content/uploads/2020/10/IDP-2017-2022.pdf

Apostolaki, S., Akinsete, E., Koundouri, P., & Samartzis, P. (2019). Freshwater: The importance of freshwater for providing ecosystem services. In Reference Module in Earth Systems and Environmental Sciences. Elsevier.

Asadieh, B., & Krakauer, N. Y. (2017). Global change in streamflow extremes under climate change over the 21st century. Hydrology and Earth System Sciences, 21(11), 5863-5874.

Barreteau, O., Caballero, Y., Hamilton, S., Jakeman, A. J., & Rinaudo, J. D. (Eds) (2016). Disentangling the complexity of groundwater dependent social-ecological systems. Integrated Groundwater Management: Concepts, Approaches and Challenges, 49-73. Springer

Byers, E., Gidden, M., Leclère, D., Balkovic, J., Burek, P., Ebi, K., & Riahi, K. (2018). Global exposure and vulnerability to multi-sector development and climate change hotspots. Environmental Research Letters, 13(5), 055012.

Chamberlain, G. L. (2019). Spirituality and water. The Routledge International Handbook of Spirituality in Society and the Professions, 76-83. New York: Routledge

Chamier, J., Schachtschneider, K., Le Maitre, D. C., Ashton, P. J., & Van Wilgen, B. W. (2012). Impacts of invasive alien plants on water quality, with particular emphasis on South Africa. Water SA, 38(2), 345-356.

Cox, D., Oosthuizen, S., & Dickens, C. (2015). Moving from Integrated Water Resources Management (IWRM) to Integrated Natural Resources Management (INRM). Water Resource Commission & Institute of Natural Resources. South Africa.

Department of Water and Sanitation (DWS), 2016. National groundwater strategy. Department of Water and Sanitation. South Africa. https://www.dws.gov.za/Groundwater/Documents/NGS_Draft-Final_04012017.pdf

Enqvist, J., & van Oyen, W. (2023). Sustainable water tariffs and inequality in post-drought Cape Town: exploring perceptions of fairness. Sustainability Science, 18(2), 891-905.

Everard, M. (2019). A socio-ecological framework supporting catchment-scale water resource stewardship. Environmental Science & Policy, 91, 50-59.

Foster, S., & Cherlet, J. (2014). The links between land use and groundwater: governance provisions and management strategies to secure a 'sustainable harvest'. GWP Perspectives Paper. Global Water Partnership.

International Labour Office (ILO). (2019). Water for improved rural livelihoods: Decent work in the rural economy. Policy guidance notes. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_729058.pdf

Intergovernmental Panel on Climate Change (IPCC) (2013). The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Eds. Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. Cambridge University Press.

Jakeman, A. J., Barreteau, O., Hunt, R. J., Rinaudo, J. D., & Ross, A. (2016). Integrated groundwater management. Springer Nature.

Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research. Social sciences, 8(9), 1-17.

Knüppe, K. (2011). The challenges facing sustainable and adaptive groundwater management in South Africa. Water SS, 37(1).

Kumar, P., Liu, W., Chu, X., Zhang, Y., & Li, Z. (2019). Integrated water resources management for an inland river basin in China. Watershed Ecology and the Environment, 1, 33-38.

Mechlem, K. (2016). Groundwater governance: The role of legal frameworks at the local and national level—Established practice and emerging trends. Water, 8(8), 347.

National Development Plan. devplan2.pdf (www.gov.za)

Department of Water and Sanitation (2018) National Water and Sanitation Master Plan: Vol 1: Call to Action V10.1. Ready for the future and ahead of the curve. Republic of South Africa Department of Water and Sanitation.

https://www.gov.za/sites/default/files/gcis_document/201911/national-water-and-sanitation-master-plandf.pdf

Paul, C. J., Weinthal, E. S., Bellemare, M. F., & Jeuland, M. A. (2016). Social capital, trust, and adaptation to climate change: Evidence from rural Ethiopia. Global Environmental Change, 36, 124-138.

Pienaar, H., Xu, Y., Braune, E., Cao, J., Dzikiti, S., & Jovanovic, N. Z. (2021). Implementation of groundwater protection measures, particularly resource-directed measures in South Africa: A review paper. Water Policy, 23(4), 819-837.

Plan, C., Hub, K., Atlas, M. W., Water, S. A., Stuff, K., Guide, C., ... & Indalo, X. (2013). Groundwater governance: A global framework for action (2011-2014)–Regional diagnosis for the Sub-Saharan Africa Region. Available on https://www.wrc.org.za/mdocs-posts/tt-578-13/ [Accessed 25, November 2023]

Scott, D. F., & Le Maitre, D. C. (1998). The interaction between vegetation and groundwater: research priorities for South Africa. Water Research Commission. South Africa.

Singh, C., & Bhagwan, R. (2020). African spirituality: Unearthing beliefs and practices for the helping professions. Social Work, 56(4), 403-415.

Sintayehu, D. W. (2018). Impact of climate change on biodiversity and associated key ecosystem services in Africa: A systematic review. Ecosystem health and sustainability, 4(9), 225-239.

Taghilou, A. A. (2022). A framework resilient social-ecological system (SES) for groundwater governance and public and private rights. Groundwater for Sustainable Development, 18, 100788.

Tapela, B. (2015). Water governance in traditional rural communities of South Africa. WRC Report NK8/1092. Water Research Commission.

UThukela District Municipality. (2021). UThukela District Municipality Integrated Development Plan 2020/21. Unpublished. The Office of the Municipal Manager.

http://www.uthukela.gov.za/media/content/documents/2021/7/o_1fedjlag81e3mkro1s8q5i8heo8.pdf?filename=APPROVED%202020-2021%20IDP%20REVIEW(FINAL).pdf

Varady, R. G., van Weert, F., Megdal, S. B., Gerlak, A., Iskandar, C. A., & House-Peters, L. (2012). Groundwater Governance: A Global Framework for Country Action. GEF ID 3726. Thematic paper No. 5: Groundwater policy and governance. 1-52. Available from https://www.wrc.org.za/wp-content/uploads/mdocs/TT%20578-13.pdf [Date accessed 25, October, 2023]