PROMOTING THE ADAPTIVE CAPACITY OF RURAL COMMUNITIES TO CLIMATE CHANGE THROUGH HOLISTIC CATCHMENT MANAGEMENT: A CASE STUDY OF GROUNDWATER DEPENDENT COMMUNITIES IN TWO CATCHMENTS

Final Report to the Water Research Commission

Prepared by:

J. Loza; K. Chueu; D. D. Cindi; N. P. Gola; B. C. Mubangizi and P. Ntshotsho

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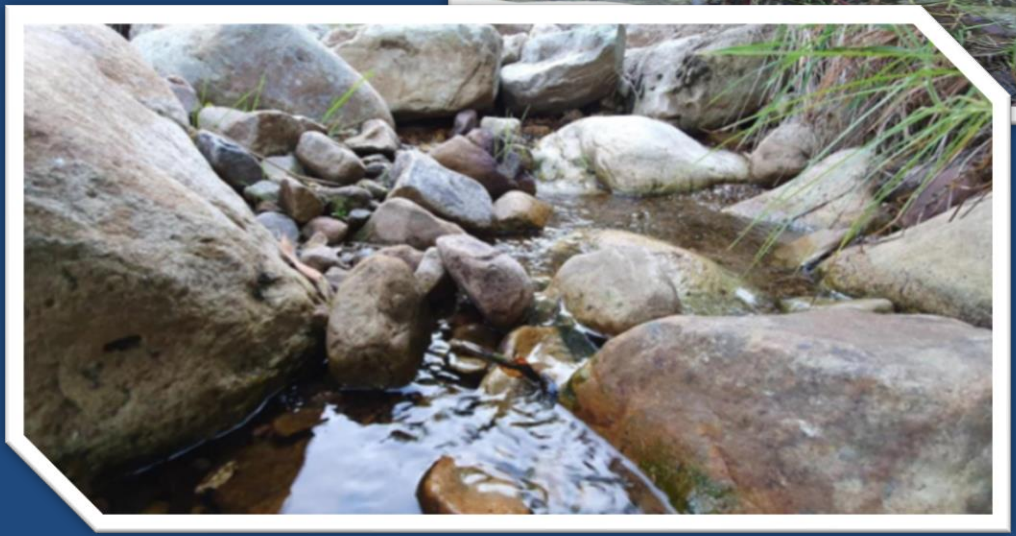

PROMOTING THE ADAPTIVE CAPACITY OF RURAL COMMUNITIES TO CLIMATE CHANGE THROUGH HOLISTIC CATCHMENT MANAGEMENT: A CASE STUDY OF GROUNDWATER DEPENDENT COMMUNITIES IN TWO CATCHMENTS

"SPRING 4 LIFE (UMTHOMBO WEMPILO)"

FINAL REPORT

WRC Project Number C2021/22-00618

Prepared by

Joyce Loza[1]; Kedibone Chueu[2]; Dan'sile Cindi[3]; Nontutuzelo Pearl Gola[3]; Betty Mubangizi[4] and Phumza Ntshotsho[5]

With inputs from

Mxolisi Mabaso[1] and Tsamaelo Malebu[3]

1 Ezemvelo KZN Wildlife

2 Department of Agriculture, Land Reform and Rural Development (DALRRD)

3 South African National Biodiversity Institute (SANBI)

4 NRF/SARChI Chair in Sustainable Rural livelihoods - University of KwaZulu-Natal (UKZN)

5 Council for Scientific and Industrial Research (CSIR)

EXECUTIVE SUMMARY

Introduction

South Africa is characterised by a large rural populace who depend on various livelihood activities, subsistence farming, migrant labour, and state grants. Post-1994, decentralisation became government policy and ushered in wall-to-wall municipal authorities, with district and local municipalities mandated to assume responsibility for service delivery in their jurisdiction areas, including water and sanitation. As part of decentralising of water resource management Chapter 7 of the National Water Act (Act 36 of 1998) makes provision for the establishment of Catchment Management Agencies by the Minister of Water and Sanitation. These are legislated structures aimed at delegating water resource management to the regional or catchment level and to involve local communities, within the framework of the national water resource strategy established in terms of Chapter 2 of the same Act.

South Africa is a water-stressed country currently facing several water challenges, including shortage of supply, degradation of ecological infrastructure responsible for water provision, poor landscape governance and water resource pollution. The situation is particularly challenging for rural municipalities. Due to substantial infrastructure backlogs, weak revenue bases and a landscape of scattered dwellings, many rural municipalities have difficulty supplying sustained water service to all their residents. Consequently, springs are a crucial resource for many households in rural communities across South Africa. The role of groundwater in South Africa has changed from an undervalued resource with a private water legal status to a source of domestic water and general livelihood to households in many villages and small towns country wide. Yet, groundwater is vulnerable to the impacts of climate change, which causes changes in hydrologic systems and the water cycle. While groundwater can be affected by non-climatic drivers, such as population growth and land-use change, those climatic changes lead to reduced groundwater recharge and increased demand for water. For many rural municipalities and communities, consideration of both climatic and non-climatic risks in groundwater management within specific catchments is vital.

Catchments are universally recognised as appropriate units of management for Integrated Water Resource Management (IWRM). A catchment-based approach is used as it enables viewing sustained groundwater management as part of an integrated socio-ecological system to address water security challenges in rural areas. This approach also intentionally links ecosystems to people's livelihoods and well-being, relying heavily on stakeholder engagement and participation to understand the range of society's demands and pressures on natural resources.

Against this backdrop, the aim of the research was five-fold, as highlighted below:

i. The co-development of innovative strategies and frameworks to respond to climate-related changes in groundwater supply;

ii. Strengthening decision-making support of governance structures and enhancement of the adaptive capacity of communities to climate-related changes in the water supply of springs;

iii. Undertaking a review of the available information, tools and mechanisms for the protection, rehabilitation, and utilisation of springs in the selected communities;

iv. Augmenting and updating existing maps and assessing the condition of commonly used springs across the two selected study areas; and

v. Understanding the relevance of social-cultural behaviours, including feelings and perceptions that influence the dependence on and restoration of ecological infrastructure.

Conceptual framing and the study's setting

This research adopted the view that expanding the adaptive capacity of policymakers, municipalities, and communities is fundamental to water security and sustainable livelihoods. Jones *et al.* (2010)'s socially-oriented framework was adopted to explore the adaptive capacity of rural communities to climate change through holistic catchment management. The framework was instructive in identifying critical elements that reflect a high adaptive capacity groundwater-dependent community of two catchments.

The study focused on communal land tenure areas under the oKhahlamba Local Municipality in KwaZulu-Natal, and Matatiele Local Municipality in the Eastern Cape, particularly the rural communities at the foothill of the Drakensberg Mountain.

Methodology

Following ethical clearance from the University of KwaZulu Natal (Appendix F), this research, grounded in a constructivist approach, used various research instruments. The data collection processes involved conducting focal group discussions, administering questionnaires, online questionnaires, one-on-one interviews, and feedback from key stakeholders. Due to the project's focus on both quantitative and qualitative outcomes, the data-gathering process was undertaken for geospatial and non-geospatial information, including spring location, type, condition, and the number of households dependent on the spring. Spatial information about the springs was extracted from existing hydrocensus databases obtained from the Non-Governmental Organisations (NGOs) involved in spring protection and from Okhahlamba Local Municipality and uThukela District Municipality Hydrocensus data sets.

In addition, a stakeholder mapping exercise was undertaken during the stakeholder engagement sessions. The stakeholder mapping aimed to develop a visual representation and understanding of the

stakeholders, and their interest and influence in the management of springs.

Lastly, the approach used to acquire information regarding the social-cultural behaviours and beliefs was through interactive group sessions during workshops and spring site visits where the community and other role players engaged on this subject. Specialist input from a Traditional Healer guided the appropriate communication methods that are culturally sensitive and do not undermine traditions and customs in the study area.

Project results and discussion presented in line with the five objectives of the study

i. Augmenting and updating existing maps and assessing the condition of commonly used springs across the two selected study areas

Many rural households in the two study sites use springs as their primary source of water provision. The water is used for multiple purposes, including drinking, washing, livestock and cultural practices.

Hydrocensus data revealed that there are correlations among the attributes relating to the spring location, type and nature, the springs' condition, and how many households depend on springs for water supply. By visualising the spring location spatially, it was noted that most of the springs are situated in the headwaters of water-related features such as rivers and wetlands.

ii. Undertaking a review of the available information, tools and mechanisms on the protection, rehabilitation, and utilisation of springs in the selected communities

Stakeholder engagement workshops identified that natural resources management is one of the drivers of change in water security, affecting the quality and quantity of water from springs in the two catchments. In particular, the perceptions from the consultation workshops and online questionnaire survey in this research highlighted poor grazing practices, increase in invasive alien plants, and solid waste disposal around the springs as critical issues that need urgent attention.

Community responses from the research concur with the DWS Protocol to Manage the Potential of Groundwater Contamination from Sanitation Practices (2003) that springs should be adequately protected and developed to prevent water contamination. However, there are no clear guidelines for implementing the Protocol at the community level. Currently, only 38% and 6% of springs are protected in the uMzimvubu and Thukela catchments respectively. The higher level of protection in the uMzimvubu catchment is driven mainly by Non-Government Organisations (NGOs) working closely with traditional authorities and the rural communities within which they work. On the other hand, the district municipality largely implements spring protection in the Thukela catchment.

There was no definite correlation between spring protection and water quality. Findings suggest that there were more instances of unacceptable water quality

than acceptable water quality from protected springs in the uMzimvubu catchment. In comparison, there were more instances of average to acceptable water quality than unacceptable water quality from unprotected springs in the Thukela Catchment. The highest incidence of unacceptable water quality was associated with unprotected springs in the uMzimvubu Catchment. The research was not conclusive on whether the state of spring protection guarantees good quality water in the study areas. It was also noted that the rudimentary nature of some of the spring protection measures makes them ineffective in preventing contamination from animal and household waste.

iii. Strengthening decision-making Support of governance structures and enhancement of the adaptive capacity of communities to climate related changes in the water supply of springs

The stakeholder mapping revealed a variety of role players in water provision. Various NGOs and research institutions fall under the interest group due to their contribution either through funding programmes or research projects associated with the management of springs. Government departments at national and provincial levels and municipalities fall under the decision makers categories as they make decisions through their decision-making roles and responsibilities associated with policies, strategies and plans that impact spring management. Local government is particularly critical in all aspects of catchment management, particularly in spring preservation. Yet, this research noted an absence of strategies for spring protection measures in municipal IDPs. The governance of springs as part of the landscape is only loosely incorporated into integrated municipal plans, if at all. As such, when spring protection structures are constructed, there are no clear rules of engagement or roles and responsibilities related to monitoring the infrastructure. Public participation in the governance of groundwater could ensure that clear norms, guidelines, and processes are in place for spring-dependent communities. There is a belief that local municipalities should serve as a focal point for developing sound groundwater management and spring protection activities. However, municipalities are constrained by a lack of human and financial resources and other sectoral departments' contributions through intergovernmental arrangements. The participants expressed a need to involve political leaders since they can affect financial allocations.

Both catchments have representation from traditional authorities who play an essential role in landscape governance in rural areas where the springs are generally located. To this end, traditional leadership institutions have the potential to either strengthen or undermine spring protection measures, thus recognising and including traditional leaders by constructively engaging with rather than marginalising them.

iv. Evaluating the relevance of social-cultural behaviours, including feelings and perceptions that influence the dependence on and restoration of ecological infrastructure

The research established that springs in the two study sites have multiple uses beyond

providing water for domestic use. Springs have extra significance because they also promote socio-cultural well-being and spirituality. Exploring spring protection strategies beyond safeguarding springs for household water consumption will be necessary to encourage the adaptive ability of rural communities in groundwater-dependent areas. The socio-cultural contribution of springs to rural communities should be considered in spring protection programs. African knowledge and belief systems on environmental sustainability could be revitalised and used broadly in environmental conservation and spring protection. A participatory approach to spring protection measures would ensure that socio-cultural aspects and beliefs are considered in managing and maintaining ecological infrastructure and protection of the springs.

v. The co-development of innovative strategies and frameworks to respond to climate-related changes in groundwater supply

The research drew on collaborative and learning-based engagements with key actors on responsive decision-making regarding the ability of communities to adapt to the effects of climate change on groundwater. Meetings with the stakeholders at study sites revealed that the vulnerabilities of groundwater-dependent communities are multi-faceted when it comes to the use of springs to meet the water supply needs of rural communities. Stakeholder engagements surfaced a range of innovative strategies to respond to groundwater management and spring protection.

Quantitative and qualitative data monitoring of springs using available citizen science tools and effective information management should incorporate springs' cultural and spiritual aspects. In this regard, awareness campaigns that involve community structures, traditional leaders, civil society structures, and local government will go a long way to cement innovative strategies that respond to changes in groundwater supply.

Recommendations

i. Incorporating spring protection plans in municipal Integrated Development Plans (IDPs) will assist in formalising rural groundwater governance and ensure representative participation of ward committees in izimbizo, as well as the annual reviews of municipal IDPs.

ii. Protecting springs and regularly monitoring their condition can be done through ongoing coordination and intergovernmental budgeting adopted in the IDP as part of the budgeting processes of municipalities.

iii. Recognising and including traditional leaders and civic structures in the area and strengthening such partnerships is essential.

iv. Maintaining and monitoring the quality of springs in line with municipal IDPs and in collaboration with traditional leaders is important.

v. Capacity and awareness building, as well as training at the community level will significantly improve the springs' quality and the preservation of infrastructure.

vi. Capacity building for local and district municipalities will ensure that municipalities implement (i) to (iv) above.

vii. Local NGOs with funding from abroad and from local municipalities have supported hydro censuses in the two catchments. While this forms a critical baseline database, we advise that more research be conducted to determine the microbiological and physico-chemical quality of spring water.

viii. Recognising and supporting the NGOs involved in spring protection and awareness programmes is encouraged.

ix. Municipalities and NGOs should consider the socio-cultural benefits of springs when designing spring protection programs.

x. Adopting an integrated catchment management approach to invasive alien plant clearing and grazing management can contribute positively to improving groundwater quality and quantity.

xi. Collaboration between municipalities, traditional leaders and civic structures is necessary to incorporate waste management for rural spaces into municipal IDPs.

xii. Disseminating study findings in user-friendly formats would be beneficial for sharing relevant research components.

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The NRF/SARChI Chair in Sustainable Rural Livelihoods funded research assistants who collected data on the vulnerabilities of groundwater and the level of awareness in groundwater-dependent communities within the uMzimvubu catchment.

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Annexure A contains a list of all the significant contributors to the study.

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ACRONYMS

ANDM	Alfred Nzo District Municipality
CDW	Community Developmental Worker
CHAT	Cultural Historical Activity Theory
CMA	Catchment Management Agency
CMAs	Catchment Management Agencies
CSA	Conservation South Africa
CSO	Civil Society Organisation
CSIR	Council for Scientific and Industrial Research
DALRRD	Department of Agriculture, Land Reform and Rural Development
DM	Drakensberg Mountain
DEF	District Environmental Forum
DRDAR	Department of Rural Development and Agrarian Reform
DWS	Department of Water and Sanitation
EC	Eastern Cape
EI	Ecological Infrastructure
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
ERS	Environmental and Rural Solutions
FAR	First Assessment Report
FGD	Focus Group Discussion

GAF	Governance Analytical Framework
IDP	Integrated Development Plan
INR	Institute of Natural Resources
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
KZN	KwaZulu-Natal
KZN COGTA	KwaZulu Natal Cooperative Governance and Traditional Affairs
KZN EDTEA	KwaZulu Natal Department of Economic Development and Environmental Affairs
MD	Maloti Drakensberg
MDTP	Maloti Drakensberg Transfrontier Programme
MISA	Municipal Infrastructure Support Agent
MLM	Matatiele Local Municipality
MTTM	Maloti Thaba Tsa Metsi
MTTMPE	Maloti Thaba Tsa Metsi Protected Environment (Proposed)
NWA	National Water Act 36 of 1998
NWRS2	Second Edition of the National Water Resource Strategy
OLM	Okhahlamba Local Municipality
PAR	Participatory Action Research
PSC	Project Steering Committee
SANBI	South African National Biodiversity Institute
SAR	Second Assessment Report

SWSA	Strategic Water Source Area
UCP	uMzimvubu Catchment Partnership
UKZN	University of KwaZulu-Natal
UTDM	uThukela District Municipality
WMA	Water Management Area
WRC	Water Research Commission
WSA	Water Services Act 108 of 1997
WSDP	Water Services Development Plan
WWF	Worldwide Fund for Nature

DEFINITIONS OF COMMONLY USED TERMS

Adaptive Capacity	The ability of a system to adjust in response to projected or actual changes in climate (Patino, 2010).
Ecological infrastructure	Naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of built or hard infrastructure and can be just as important for providing services and underpinning socio-economic development. Ecological infrastructure does this by providing cost effective, long-term solutions to service delivery that can supplement, and sometimes-even substitute, built infrastructure solutions. Ecological infrastructure includes healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape (SANBI, 2019).
Ecological rehabilitation	Rehabilitation emphasizes the reparation of ecosystem processes, productivity, and services, whereas the goals of restoration also include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure (SER, 2004). The goal of rehabilitation projects is not native ecosystem recovery, but rather reinstating a level of ecosystem functioning for renewed and ongoing provision of ecosystem services potentially derived from non-native ecosystems as well (SER, 2019).
Hydrocensus	A hydrocensus is a task that involves gathering information on water features, water supply sources and sources of potential water pollution in a particular site or area (DWAF, 2004)
Spring	The emergence of groundwater at the land surface, usually at a clearly defined point; the water may flow strongly or just ooze or seep out (http://www.wrc.org.za/wp-content/uploads/mdocs/Groundwater%20book_web.pdf)
Thukela	Refers to the river catchment.
uThukela	Refers to the district municipality.

CHAPTER 1: BACKGROUND AND CONTEXT

1.1 Introduction

Climate change is the biggest threat currently facing humanity, with its negative impacts projected to hit the world's most vulnerable populations the hardest. One of the most significant negative impacts of climate change is already being experienced on water security. As a result, water as a subject has become the face of the climate change discourse, particularly in the South African context. The negative impacts of climate change on the rural poor are further compounded by declining levels of resilience of ecological systems, due to widespread biodiversity loss and ecological degradation (IPBES, 2018). Rural livelihoods are marginalised by their reliance on the rapidly degrading ecological infrastructure (EI) (defined as "Naturally functioning ecosystems that deliver valuable services to people", SANBI, 2013). They are further marginalised by poorly resourced rural municipalities that cannot provide efficient and effective essential services. The glaring inequalities in access to resources and functional infrastructure were brought under the spotlight during the COVID-19 crisis when the lack of access to clean running water was brought into sharp focus.

South Africa is a water stressed country currently facing water security challenges, including shortage of supply, degradation of EI responsible for water supply, poor landscape governance and water resource pollution. These are further exacerbated by ageing built infrastructure or the non-existence of such infrastructure, a growing population, and the impact of climate change. Water scarcity poses a serious threat to economic growth, as the development agenda of the country's most strategic sectors such agriculture, energy security, mining, tourism, urban and rural development depend entirely on adequate water supply. This makes water security central to realising Vision 2030. At present, more than 98% of the reliable available surface water is already prescribed, and demand already outstrips supply in most catchments, with the Department of Water and Sanitation cautioning that unless the current water challenges are addressed, the country will be facing a disastrous 17% deficit in water supply by 2030 (Department of Water and Sanitation, 2018).

Freshwater ecosystems play a crucial role in the delivery of water-related services such as water provisioning and purification, flow regulation and flood attenuation, and waste dilution and transport. The potential of naturally functioning ecosystems to provide water supply services is of concern as surface yields approach full utilisation. Recognition of and investment in EI is fundamental to ensuring quality and adequate supply of water. Important EI, such as rivers, wetlands, and mountain catchments, is crucial for water security and complements bulk infrastructure such as dams and pipes that facilitate storage and distribution of water. Healthy and well managed EI generates and produces quality and

adequate water supply, thereby contributing immensely to the country's development agenda.

Catchments are universally recognized as appropriate units of management for Integrated Water Resource Management (IWRM). This catchment-based approach allows the management of catchments as integrated socio-ecological systems to address water security challenges. This approach also intentionally links ecosystems to people's livelihoods and well-being, relying heavily on stakeholder engagement and participation to understand the range of societal demands and pressures on natural resources. Ultimately, a catchment-based approach makes sense when considering the need to improve how society adapts to climate change.

Springs are a crucial resource for water provision for a significant number of households in rural communities across South Africa. The importance of groundwater in South Africa has been brought into the public domain through the National Water Act, 1998 (Act 36 of 1998). The role of groundwater in South Africa has undergone a major change from an undervalued resource with a 'private water legal status' to a source of domestic water and general livelihood to more than 50% of communities in thousands of villages and small towns country-wide as part of the national drive to meet basic water needs (DWS, 2016). Groundwater is vulnerable to climate change which causes changes in hydrologic systems and the water cycle. Climatic changes lead to reduced groundwater recharge and increased demand. The sensitivity of groundwater to drought depends on the amount of recharge. Groundwater can also be affected by non-climatic drivers, such as population growth, need for animal and human food and land-use change. Active consideration of both climatic and non-climatic risks in groundwater management is vital.

Groundwater governance is interpreted as the exercise of appropriate authority to promote responsible collective action for sustainable and efficient resource utilisation and protection in the interest of humankind and dependent ecosystems (Foster *et al.* 2013). Kulkarni *et al.* (2000) define groundwater governance as political, social, economic, and administrative systems that explicitly aim to develop and manage groundwater resources at different levels of society that rely mainly on groundwater resources. This definition includes all mechanisms relating to financing, knowledge and technical capacity, and the rights and responsibilities of water users and sector players. Kulkarni *et al.* (2000), drawing from Blomquist (1985) and Ostrom (1990), point out two fundamental challenges in the complexity of groundwater governance. Firstly, groundwater is not confined to any one piece of land. Secondly, it is an invisible shared pool resource since it is a subsoil resource and largely unseen. This complexity sets down the logic for institutions primarily in the forming of a set of rules, norms, and values in groundwater governance, further strengthening the case for a balanced development and ecosystem approach toward groundwater governance.

The concept of adaptive capacity to climate change impacts first appeared in the Intergovernmental Panel on Climate Change (IPCC)'s first assessment report (FAR) in 1990. The concept was later expanded upon in the IPCC Second Assessment Report (SAR) in 1995. Since then, studies on climate and related aspects have witnessed a significant shift from impact assessments to understanding what drives vulnerability and what issues enable the adaptation of communities to climate change. The IPCC's SAR describes the adaptive capacity as "the ability to adapt to new climatic conditions, which determines the societies' vulnerability to climate change", while Patino (2010) defines adaptive capacity as the ability of a system to adjust in response to projected or actual changes in climate. The SAR highlights the fundamental determinants of adaptive capacity, namely technological advances, institutional arrangements, availability of financing, and information exchange (IPCC, 1995).

Many authors have expanded on the determinants laid out by the IPCC in attempt to operationalise and measure the determinants of adaptive capacity. For example, Yohe & Tol (2002) identify an additional four determinants of adaptive capacity, which are:

(i) The stock of human capital, including education and personal security,

(ii) The stock of social capital, including the definition of property rights,

(iii) The system's access to risk spreading processes, and

(iv) The public's perceived attribution of the source of stress and the significance of exposure to its local manifestations.

This study adopted Jones *et al.*'s socially-oriented framework (2010) as depicted in the table below. The framework incorporates the original IPCC's determinants and Yohe and Tol's determinants, while also including two other determinants of (i) Innovation and the ability to explore niche solutions to take advantage of the new opportunities and (ii) Flexible forward-looking decision-making and governance.

Table 1.1: *Features of the Local Adaptive Capacity Framework*

Adaptive capacity at the local level	
Characteristics	**Features that reflect a high adaptive capacity**
Asset base	Availability of key assets that allow the system to respond to evolving circumstances
Institutions and entitlements	Existence of an appropriate and evolving institutional environment that allows fair access and entitlement to key assets and capitals
Knowledge and Information	the system has the ability to collect, analyse and disseminate knowledge and information in support of adoption activities
Innovation	The system creates an enabling environment to foster innovation and experimentation as well as the ability to explore niche solutions in order to take advantage of the new opportunities
Flexible forward-looking decision-making and governance	The system is able to anticipate, incorporate and respond to changes with regards to its governance structures and future planning

Source: Jones et al. (2010)

1.2 Context and Motivation

1.2.1 Study area

The study focused on communal land tenure areas under the oKhahlamba Local Municipality in KwaZulu-Natal, and Matatiele Local Municipality in the Eastern Cape, particularly the rural communities at the foot of the Drakensberg Mountain. The map below (Figure 1.1) depicts the study area. The study area falls within two of South Africa's Strategic Water Source Areas (SWSAs) for surface water (Northern Drakensberg and Eastern Cape Drakensberg). Strategic Water Source Areas refer to 10% of the land surface area of South Africa, Lesotho and Eswatini that provides a disproportionate 50% of water runoff to these three countries' (Le Maître *et al.*, 2018). Six of South Africa's 22 SWSAs are situated in the Drakensberg Mountain region. Of further importance, this region forms part of the recently identified groundwater SWSAs (Le Maître *et al.*, 2020). Additionally, SWSAs for groundwater have also been identified based on strategic use and recognising that key components of surface water are dependent on groundwater recharge. There is a joint process by the Department of Forestry, Fisheries and the Environment (DFFE) and the Department of Water and Sanitation (DWS) with support from various stakeholders to secure SWSAs, highlighting the importance of intergovernmental relations in the management of water resources.

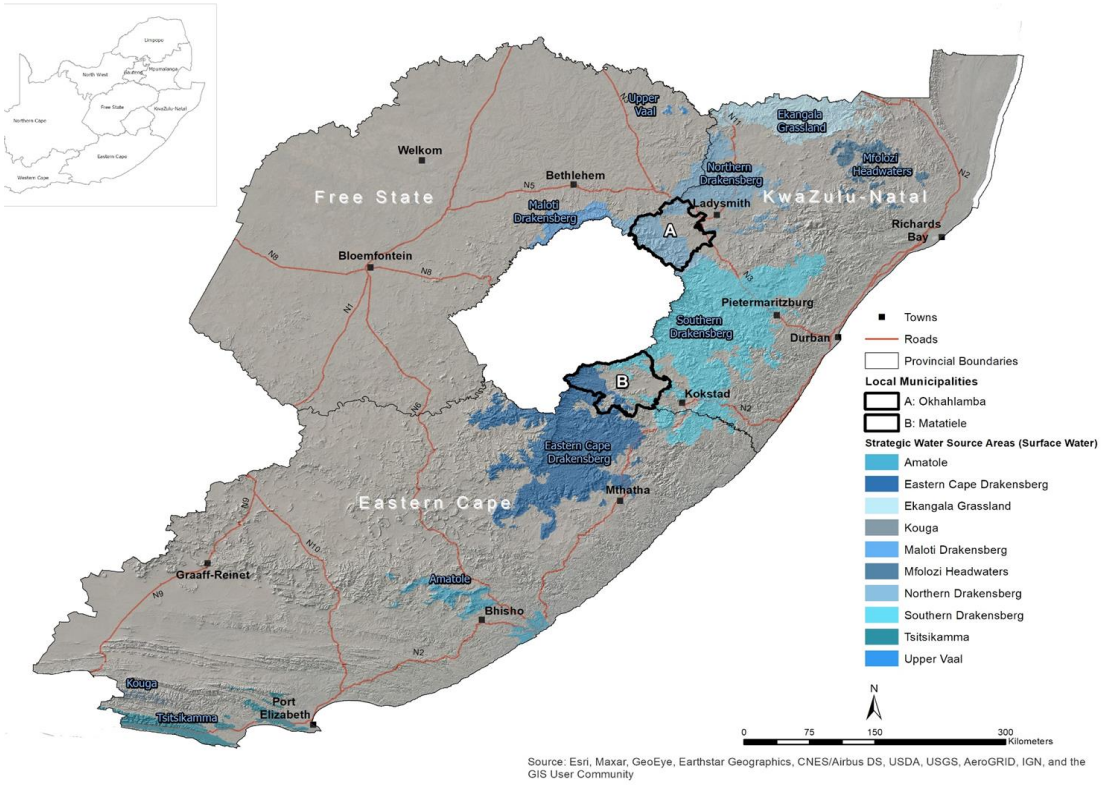

Figure 1.1: *Map showing the focus municipalities within the Thukela and uMzimvubu River catchments located within SWSAs.*

The Thukela and uMzimvubu River catchments are critical water sources for Eastern Cape, KwaZulu Natal, Free State and Gauteng provinces, with more than 50% of Gauteng's water needs supplied by the Thukela DM region. Despite these areas being critical water sources, their ability to provide water is impacted upon by several issues such as climate change, invasive alien plants, poorly managed livestock grazing, inappropriate spatial planning, degradation of grasslands resulting in increased run-off, causing extensive soil erosion and unpredictable water supply and exacerbating the already vulnerable water access situation in the two catchments.

Alfred Nzo District Municipality (ANDM), within which Matatiele LM falls, is becoming a water-scarce municipality with several dam water levels dropping below 30% due to drought (ANDM IDP 2019/20, 2019). Similarly, nearly 10% of the uMzimvubu upper catchment is degrading because of various drivers of ecosystem degradation. Furthermore, an increase in conditions that promote wildfires (hotter, drier and windier conditions); reduced rainfall resulting in the reduction of run-off; and decreased soil moisture as a result of less rain and higher temperatures are amongst the expected impacts of climate change.

Climate change coupled with inappropriate catchment management have significantly affected ground water supply from springs. Springs provide water to a significant number of

households in rural communities across South Africa, and the communities of the uMzimvubu (Eastern Cape Province) and the Thukela River (KwaZulu-Natal Province) catchments are no exception. In their respective Integrated Development Plans, the Matatiele and oKhahlamba local municipalities (located in uMzimvubu and Thukela catchments respectively) recorded serious water supply backlogs (oKhahlamba Local Municipality IDP, 2019; Alfred Nzo District Municipality IDP, 2019). The Water Services Act (WSA) (Act No. 108 of 1997) recognises and makes provision for the right of access to basic water supply and sanitation to ensure sufficient water. In terms of this Act, the responsibility of ensuring access to water services lies with Water Service Authorities (municipalities). It is thus in the best interest of various partners to explore opportunities for implementing innovative interventions to protect and improve springs as well as enhance water governance in these rural communities.

1.2.2. Socio-economic context

Communities in the study areas are generally poor. The demographics statistics depict that 40% of the households within the ANDM live below the 'poverty line' (R800/$50 per month) with 30% overall unemployment rate and 53% youth unemployment (ANDM Census, 2016). The poverty and unemployment situation is not much different in Okhahlamba Local Municipality (OLM), with the 2016 OLM census report depicting a 43,4% unemployment rate in 2011 (nothing reported in 2016), and 52,3% youth unemployment rate in 2011 (no statistics for 2016). Additionally, the OLM IDP 2018/19 reports that a significant part of the population (43%) does not receive any form of income, whilst 28% earn below R400 per month and 11% earn between R801 and R1600 per month.

In terms of household water services, 55% of the population in ANDM collect water from natural sources such as rivers and springs, while only 11% of the population in uThukela District Municipality get their water from natural sources (StatsSA, 2016). The 2011 and 2016 census results for OLM depict a decrease from 16,9% - 5,9% in piped water inside a dwelling. Furthermore, there is an emphasis on water needs being augmented by groundwater, 20% reliance on boreholes and 19% on springs (OLM IDP, 2018/19). It is for this reason that the management and protection of springs be understood to inform policy responses.

1.2.3 Governance context

Governance has been defined by the United Nations Development programme (UNDP) as: 'the exercise of political, economic and administrative authority in the management of a nation's affairs at all levels — and thus comprises the mechanisms, processes and institutions through which the citizens of the nation articulate their interests, mediate their differences and fulfil their legal rights and obligations." (DWS, 2016). In terms of the political context, the targeted communities are governed through traditional and democratic governance systems. Traditional Authorities have acceptable traditional systems with which they govern certain

community social matters. The allocation of funds to address water service delivery is through the Local and the District Municipality of both provinces as mandated by the Constitution. District Municipalities have Water Services Development Plans (WSDPs) that guide water service provision to communities to ensure delivery of good quality drinking water. However, the rural areas in this study do not have the advanced bulk water supply infrastructure such as water treatment works, waste-water treatment works and water networks. The highest water service delivery backlogs are in rural settings.

The National Water Act (No. 36 of 1998) (NWA)) provides for the establishment of Catchment Management Agencies (CMAs) as statutory bodies responsible for integrated water resource management at the catchment level. CMAs are responsible for managing water resources and coordinating the functions of other water management institutions within their respective Water Management Areas (WMAs). According to the NWA, a Catchment Management Agency (CMA) must be established for each Water Management Area (WMA) delineated through the National Water Resource Strategy (NWRS). The 2nd Edition of the National Water Resource Strategy (NWRS2) delineated 9 WMAs. The Mzimvubu catchment is located on the Mzimvubu-Tsitsikamma WMA and the Thukela catchment on the Pongola-Mthamvuna WMA. The Mzimvubu-Tsitsikamma and the Pongola-Mthamvuna WMAs currently do not have fully functional CMAs, they still function as proto-CMAs.

Catchment partnerships, typically as self-organised stakeholder groups, play an essential role in closing the gap and collaborating and coordinating activities in areas where CMAs are not fully functional with designated roles and responsibilities. These partnerships use collaborative water governance approaches that allow multi-sector views to understand the demands and pressures on the catchments. A largely undeveloped rural communal landscape characterises both catchments where the study took place, with under-resourced local authorities resulting in governance and institutional challenges. However, it is worth noting that partnership initiatives such as the uMzimvubu Catchment Partnership (UCP) and the Bergville Catchment Management Forum have developed in these areas. Such initiatives recognise the potential of the catchment to provide a wide range of ecosystem services to sustain the livelihoods of the surrounding rural communities and are of utmost importance in linking activities in the catchments.

1.2.4 Legislative context

South Africa has a wealth of policy and legislative frameworks addressing resource management, including regulating access to and provision of water. The Constitution of the Republic of South Africa recognises the right of access to sufficient water of adequate quality, as being essential to a good quality of life. The National Water Act 36 of 1998 (NWA) is the primary legislation that regulates water resource protection by specifically providing for policies, strategies, and guidelines to be formulated to bring water resource protection into

policy. According to the NWA the definition of a water resource includes a watercourse (river or spring, natural channel, wetland and lake or dam), surface water, aquifer as well as an estuary (NWA Chapter 1, Section 1 (xxiv)). Water resources are more than just water, their condition is dependent on the water quality and quantity, as well as the interaction of biotic and abiotic components with the aquatic ecosystems.

Chapter 3 of the NWA recognises three Resource Directed Measures (RDM) to facilitate protection of water resources; Classification of water resources, setting the Reserve and determining the Resource Quality Objectives (RQOs). The RDM are a joint expression of the agreed state of the water resource (including surface water and groundwater) for a desired level of protection. The classification of the country's significant water resources into Management Classes involves a process of research, and engagement with key stakeholders who provide the necessary technical input related to the attributes of the catchment. The Management Class of the resource is an integral part of the water resource protections, as it determines the level of protection that can be afforded the resource. According to the NWA the determination of a Management Class of a water resource must consider ecological integrity and the needs of water users.

The RQOs are established clear goals relating to the quality of water resources, finding a balance between protecting and sustaining the resources, and the need to use them (NWA Chapter 3). The RQOs must be determined for each water resource in response to the agreed Management Class as required by the NWA. RQOs are narrative or numeric descriptions that describe the objectives for management of a resource and can only be implemented and achieved if the use of the water resource is properly regulated. The Classification of the uMzimvubu catchment and determination of it RQOs was finalised and gazetted in 2018. The classification and determination of the RQOs for the Thukela catchment was initiated in 2019 and is now in the gazetting process. The challenge with RQOs that they require collaborative water resource management with other sectors. In the absence of CMAs to implement RQOS through coordination, and compliance monitoring and enforcement it is difficult to ensure that these RQOS are achieved. Another challenge is that RQOs are determined by the National Department of Water and Sanitation and meant to be implemented at catchment level by CMAs or the Regional Departments of Water and Sanitation in cases where CMAs are not fully established.

The Reserve is defined as the quality and quantity of water required for basic human needs and protection of aquatic ecosystems for ecologically sustainable development and use of water resources. The NWA requires that the Reserve be determined after the Management Class of the water resource has been determined. If the Management Class has not yet been determined, a Preliminary Reserve (NWA Chapter 3, Section 17) must be determined before authorisation for water use (NWA Chapter 4, Section 22). Determination of the Reserve for basic human needs and the ecological requirements ensures continued use of the water resource while maintaining the health and efficient functioning for the ecosystem at the

management class agreed upon. The Reserve for both the uMzimvubu and Thukela catchments has not yet been determined, water use authorisation including that of water service authorities is still based on the preliminary Reserve. In addition to the Constitution and the NWA, other pieces of legislation that are relevant to the management of springs are discussed below. Also see Appendix A for a summary of these statutes.

The Department of Water and Sanitation has developed a National Groundwater Strategy (NGS) to facilitate groundwater utilisation as part of water resource management through a framework for groundwater governance in South Africa (DWS 2016). The NGS is intended to be a sub-strategy of the National Water Resource Strategy (NWRS) and recognises the contribution that groundwater can make to the challenges of water supply for domestic use to households in the remote rural areas where water services are often unacceptable or non-existent. There are various climate change strategies developed at national, provincial, and local government level. Most of these strategies include water resource management without specifically addressing challenges related to groundwater supply and natural resources management.

According to the NWA, CMAs are responsible for the development of Catchment Management Strategies (CMS) for their respective WMAs. A CMS is a legal document providing the vision and strategic actions to address integrated water resource management at a regional or local level. Due to not being fully functional CMAs with designated functions, roles and responsibilities, the Pongola-uMzimkhulu and Mzimvubu-Tsitsikamma are still proto-CMAs. They therefore have not developed catchment management strategies to guide water resource management at regional and catchment level. In the absence of catchment management strategies for their respective catchments, water resource management is guided by national, provincial, and local government policies and legislation with supporting strategies and plans. This requires effective cooperative governance (three spheres of government at national, provincial, and local government working together) to provide water service delivery to the citizens. The Intergovernmental Relations Framework (Act 13 of 2005) intends to establish a framework for the national, provincial, and local government to promote and facilitate intergovernmental relations.

Although the three spheres of government at national, provincial, and local are quite distinctive, they are interdependent and interrelated. The establishment of water management institutions is based on hydrological rather than political boundaries, resulting in misalignment between local government demarcations and water regulatory boundaries; this poses a challenge for water resource management and calls for innovative strategies to promote relations and partnerships not only vertically across national, provincial and local government but also horizontally across departments. It also remains in the interest of catchment stakeholders to self-organise to assist DWS with coordinating water resource management interventions.

1.3 Key drivers of change in the study areas

Most of the population in sub-Saharan Africa remains rural-based and reliant on natural resources for composite economic, social, and cultural benefits (Plaas, 2022). Integrated Catchment Management (ICM) has been recognised as a principled approach to natural resource management (NRM). Natural resources management refers to the sustainable utilization of major natural resources, such as land, water, air, minerals, plants and animals, and the ecosystem (Muralikrishna & Manickam, 2017). For the context of this report, natural resources refer to land, water, and plants/vegetation. An integrated catchment management approach that takes into consideration key drivers of change has the potential to promote sustainable land and water management. Such an approach is underpinned by the need for interdisciplinary and community-based collaboration.

1.3.1 Rangeland management

Rangelands cover approximately 70% of the land surface of South Africa, and therefore represent the single biggest form of land-use in the country. Rangelands are complex systems that are characterized by linkages and feedbacks between ecological and social processes across a range of temporal and spatial variables (Vetter, 2009). Rural communities in South Africa are heavily reliant on rangelands as the main natural resource base for their livelihood, these include the rural communities that are located near the Thukela and uMzimvubu River catchments.

Communal rangelands make up only 13% of agricultural land in South Africa (Samuels *et al.*, 2007). Although the communal rangelands are mainly used by grazing livestock, rural communities also rely on them for other benefits such as harvesting firewood, building materials, and medicinal plants, as well as for cultural practices. These rural communities occupy communally managed rangelands and use a common pool of natural resources such as grazing land.

Rangelands in good condition provide a more stable groundcover and better soil moisture retention, thereby able to offset the risks associated with impacts of climate change. Reduced ground cover results in decreased interception of precipitation, leading to increased runoff and soil erosion. Therefore, to avoid rangeland degradation through overgrazing and other inappropriate practices, a collective grazing management plan should be co-developed at community level to ensure that the valuable rangeland resources are managed in a sustainable manner by all users.

There are numerous examples of community grazing approaches/ models that are advocated for rural communities in South Africa. Conservation South Africa (CSA) has been championing the establishment of Grazing Associations through implementation of

Conservation Agreements with farmers in selected rural areas of the Eastern Cape, Northern Cape, and Limpopo (CSA, 2018). By signing Conservation Agreements, farmers commit to sustainable approaches to grazing, water management, and stock numbers and in return, they get incentives such as access to veterinary medication and markets (livestock auctions) through the Meat Naturally Pty. In the upper uMzimvubu catchment, CSA and Environmental and Rural Solutions (ERS) are working with rural communities to promote rangeland stewardship with support from the local Traditional Authorities.

The Conservation of Agricultural Resources Act (Act No. 43 of 1983) makes provision for control over the utilisation of the country's natural agricultural resources to promote conservation of the soil, water resources and vegetation, and to combat weeds and invasive alien plants. In terms of Regulation 10 of CARA, the National Long term Grazing Capacity Map was promulgated to give guidance to land-users on use of rangeland for animal production. The map depicts long-term grazing norms of a veld in good condition, and it does not indicate current veld condition nor the current biomass (South Africa, 2018). The grazing capacity of a degraded rangeland is generally lower than that of rangeland in good condition (Jordaan, 2020). Grazing capacity (also known as carrying capacity) is defined as the amount of forage available for grazing animals in a specific pasture or field. Over-estimation of grazing capacity can result in rangeland degradation.

Figures 1.2 and 1.3 show the grazing capacity maps for the Alfred Nzo and uThukela District Municipalities. Grazing capacity (expressed in hectares per livestock unit (ha/LSU)) in the locality of the study area in the Eastern Cape is marginally lower than that in KZN, ranging from 2.5 to 5 ha/LSU. In fact, most of the study area falls in areas of between 3.5 and 5 ha/LSU. In contrast, the study sites in KZN fall in areas with a slightly higher grazing capacity, ranging between 2.5 and 4 ha/LSU.

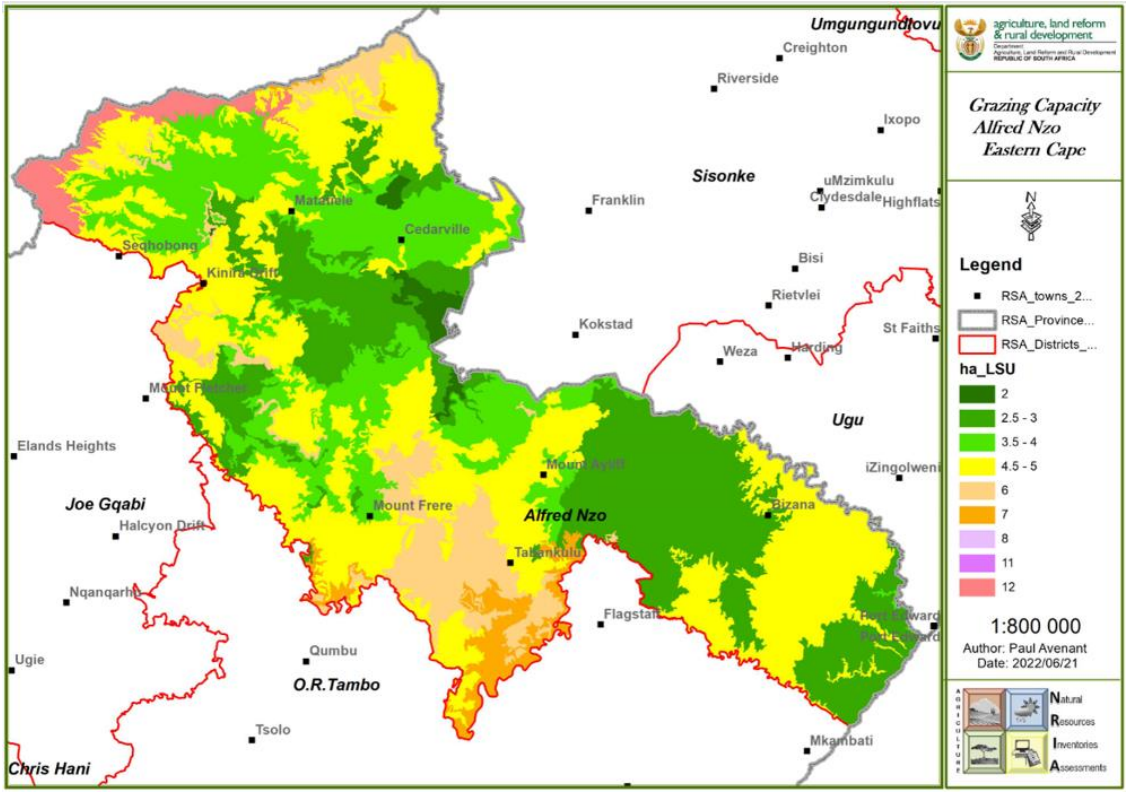

Figure 1.2: *Grazing Capacity Map for Alfred Nzo District Municipality (Source: Avenant, 2022).*

These maps were produced at district scale, and ground- truthing that includes veld condition assessments at local level are recommended to fully understand dynamics of natural resource management in a changing climate.

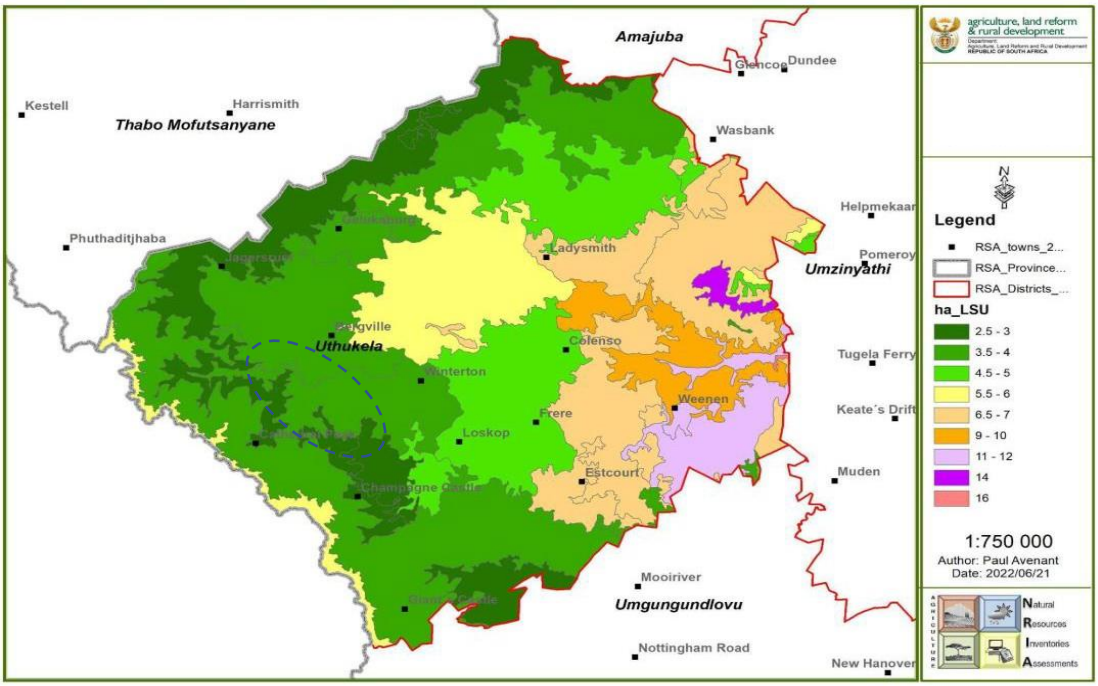

Figure 1.3: *Grazing Capacity Map for uThukela District Municipality (Source: Avenant, 2022).*

1.3.2 Invasive alien plants

Invasion by alien tree species is a significant and well-documented problem in South African rangelands (Van Wilgen *et al.,* 2008; Yapi *et al.,* 2018; Gouws & Shackleton, 2019). The associated negative ecological impacts include reduction in grazing capacity, basal cover, and soil moisture content. Australian *Acacia* species, such as *Acacia mearnsii* (black wattle) and *Acacia dealbata* (silver wattle), have a particularly significant impact on rangelands due to their ability to displace native vegetation by forming dense stands (De Neergaard *et al.* 2005; Lorenzo *et al.* 2010). These invasive tree species are known to have severe negative impacts on water resources because of their higher evapotranspiration rates, which result in a reduction of river flows and mean annual runoff (Le Maître *et al.,* 2020). Primary catchments in the Eastern Cape and KwaZulu-Natal are among those reported to be most severely affected, with reductions of more than 5% in mean annual runoff. These impacts are especially pronounced in riparian areas and areas where groundwater is accessible, estimated to be around 1.2 to 2 times the impact in dryland areas (Le Maître *et al.,* 2020). Another negative impact of invasion by alien plant species is the alteration of fire regimes, primarily because of changes in fuel loads (Brooks *et al.,* 2004). A combination of poor grazing practices, alien plant invasion and maladaptive fire regimes can lead to increased levels of soil erosion, which, in turn, can increase the siltation of water bodies. The Eastern Cape and KwaZulu-Natal provinces are rated second and third, respectively, in terms of gully erosion in South Africa (Le Roux, 2011), implying that the soils in these regions are naturally

susceptible to erosion.

Efforts to deal with the problem of invasive alien plants have been underway in the uMzimvubu catchment for over a decade, especially under the auspices of the national government's Working for Water programme (Ntshotsho *et al.,* 2016). These clearing efforts use a holistic approach to catchment management, combining veld management techniques that are embedded in traditional ecological knowledge (Berkes *et al.,* 2000) with evidence-based tree clearing methods, fire management and donga rehabilitation. Verbal accounts of water gains (as evidenced by streams flowing even during the dry season) and published accounts of veld condition improvement resulting in improvements in cattle condition (Stanway 2016) suggest that the programme is resulting in both ecological and societal gains for the communities in the uMzimvubu Catchment. While cognisant of the importance of considering context, an exploration of the potential to duplicate such a holistic approach in other catchments such as the Thukela catchment is recommended.

1.3.3 Waste management

Poor waste management is one the serious challenges that continues to threaten sustainable rangeland management in rural communities. Local sanitation experts and Alfred Nzo District Municipality (ANDM) officials indicated that water quality is being impacted by herders and livestock in the upper reaches of the uMzimvubu catchment (CSA, 2018). As a result, CSA has developed Veld Sanitation guideline to assist in addressing the waste management challenges affecting rural communities. The veld sanitation guideline is centred on key messages at the intersection of good practices for sanitation, hygiene practices, land-use and water resource protection in support of the World Health Organization (WHO)'s One Health initiative (CSA, 2018). Viljoen *et al.* (2021) suggests that budget constraints and poor planning have resulted in inadequate investments in rural waste management by the municipalities servicing them. The Waste Research Development and Innovation (RDI) Roadmap recommended several strategic and national priorities through a 10-year plan that was geared to make a positive and meaningful contribution towards growing and transforming the South African waste sector (Department of Science and Technology, 2014).

1.4 Project Aims

The study sought to address several interlinked aims, as depicted in below.

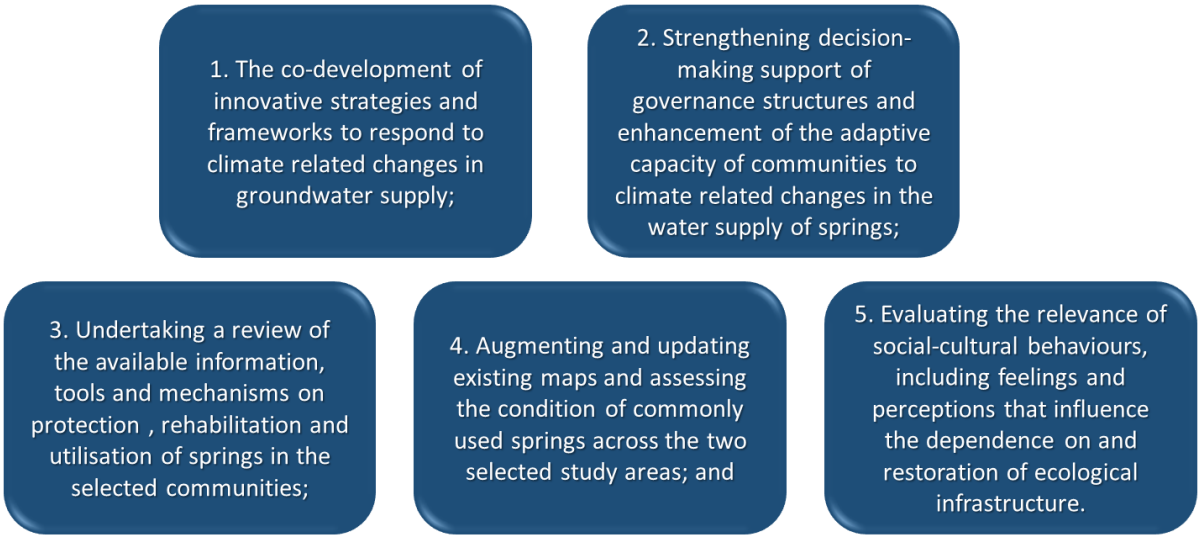

Figure 1.4: *Schematic presentation of the aims of the study.*

1.5. Outcomes And Expected Impacts

The following outcomes and impacts were anticipated from the study:

- Enhanced cooperative governance capacity amongst partners through advocacy (clarification on the segregation of duties by stakeholders and partners, including the participation of local communities in decision making on water security matters).

- Improved documentation and appreciation of springs as critical water resources for rural communities (through answering questions such as where the springs are, how well do they serve household water needs, where are the gaps in knowledge).

- Practical/effective implementation framework for the improved protection of springs.

In summary, this WRC-funded study sought to understand the adaptive capacity of ground-water dependent rural communities to the impacts of climate change on spring water supply, through an understanding of holistic catchment management. The project entitled "*Promoting the adaptive capacity of rural communities to climate change through holistic catchment management: a case study of groundwater-dependent communities in two catchments."* was a

multi-institution collaborative project. To capture the ideals of the work, **"SPRING 4 LIFE (UMTHOMBO WEMPILO)"** was adopted as the project's tagline.

CHAPTER 2: METHODOLOGY

This chapter outlines the approach and methodology adopted to address the aims of the project. Such information includes stakeholder engagement and mapping, co-development of innovative strategies and frameworks to respond to climate related changes in groundwater supply, approaches to strengthen decision-making support of governance structures and enhance the adaptive capacity of communities to climate related changes in the water supply of springs and evaluating the relevance of social-cultural behaviours including feelings and perceptions that influence the dependency to and restoration of ecological infrastructure.

2.1 Stakeholder engagement and mapping

Stakeholder mapping is a methodological approach used to analyse how institutions and organisations function and interact with key stakeholders engaged in those institutions (Aligica, 2006; Mubangizi, 2020). The significance of maps, in general, is that they are useful as a navigation tool because a visual presentation is easy to understand and has the potential to be used by multiple stakeholders" (Underwood *et al.*, 2019, p. 139). Identifying relevant stakeholders in the beginning of the project is an important step for effective stakeholder engagement. However, having a database or list of stakeholders does not necessarily translate to interest and/or influence of the stakeholders on the project. It was important to first map out the levels of interest of different stakeholders in relation to the influence associated with groundwater (springs in particular) supply. Stakeholder composition and interests may change over time, this was therefore not a static process.

The stakeholder mapping was aimed at first developing an understanding of the stakeholders' interest and influence using information from the above-mentioned stakeholder engagement sessions and then mapping the stakeholders to get a visual representation. There are several available stakeholder analysis techniques but a simpler and commonly used one is a stakeholder plot on a matrix which has two key stakeholder attributes as the axes (Mathur *et al.*, 2007). The interest versus influence matrix was used for the stakeholder analysis to understand the level of interest and magnitude of influence that catchment stakeholders have in relation to the project and its aims (Brouwer *et al.*, 2016). Table 2.1 (below) describes the meaning of "*interest*" and "*influence*" in terms of this report. Previous interaction with the stakeholders from various platforms was considered when determining interest and influence.

Table 2.1: *Description of the interest and influence of the stakeholder matrix.*

COMPONENT	DESCRIPTION
Stakeholder	An individual or organisation with an interest in the outcome of a programme or activity, either as a result of being affected by it or being able to influence it (DFID, 2003).
Interest	Interest of the stakeholder in the success or failure of an activity (DFID, 2003)
Influence	The power that the stakeholder has to influence decisions and/or facilitate or impede the achievement of an activity's objectives (DFID, 2003; WHO, 2005)

Stakeholder mapping was undertaken using the Kumu platform. Stakeholder engagements were held in both the Thukela and uMzimvubu River catchments, and it is worth noting that stakeholder engagement continued throughout the duration of the project. The stakeholder engagement process in the uMzimvubu catchment was done through the uMzimvubu Catchment Partnership (UCP) where updates on spring protection were discussed. Engagements were through virtual and physical meetings and workshops. The project team also engaged community stakeholders through questionnaires to gather information pertaining to springs (Appendix B). In the Thukela catchment stakeholder engagement were held with AmaZizi Traditional Authority (TA), as well as AmaZizi Project Steering Committee (PSC), which is a group of community members that represent the interest of the community in spring water supply for the area of AmaZizi. There were also engagements with the AmaSwazi TA and its PSC, as well as the AmaNgwane TA and its PSC.

In both catchments, stakeholders were initially identified and clustered or grouped into government departments (at national and provincial level), local government (district and local municipalities), government agencies/entities (at national and provincial level), academia and research institutions for the two respective catchments. After this, stakeholders were further analysed and grouped according to their interest in the project (springs as a resource). These interests are categorised as below:

- **Interest group**: Stakeholders who have an interest or opinion about or can affect the use of springs;
- **User group**: Stakeholders who use the springs;
- **Beneficiaries:** Stakeholders who may benefit from the use of springs;

- **Decision makers:** Stakeholders who make decisions about the use of springs (Tearfund, 2020).

Overall, it was noted that institutions and organizations and their features, such as networks, policies, principles, and practices, make up a governance system. The stakeholder engagements highlight that associations can help create connections among key dimensions of effective landscape governance to influence strategies and frameworks for adaptation to climate change in groundwater dependent communities. An understanding and exploration of key stakeholders in landscape governance is thus a critical foundation in developing innovative strategies for adaptation to changes in groundwater.

2.2 Spatial analysis

Due to the project's focus on both quantitative and qualitative outcomes, the data gathering process was undertaken for *geospatial* and *non-geospatial* information. Geospatial information refers to data that is linked to a particular location on earth while non-spatial information refers to any information independent of location (i.e., observation, reflection, etc.). Non-geospatial information was derived in the form of questionnaires, behavioural attributes, or patterns. Geographical information was collected to depict spring location, type, condition, and number of dependents on the spring (hydrocensus) and streamflow. Streamflow is one of essential climatic variables and key factors that can be used to evaluate climate variation, including understanding inherent hydrological processes that affect water resource management, floods, and droughts (Abtew *et al.*, 2009). Datasets considered in the present study were derived from three streamflow stations shown in Table 2.2.

Table 2.2: *Stations for streamflow datasets*

Station ID	Longitude	Latitude	Percentage of data gap
V1H009	-28,8925	29,77047	21,08%
V1H026	-28,7219	29,37572	3,05%
V1H041	-28,8126	29,31058	3,78%

Source: South African Weather Service

Spatial information about the springs in the uMzimvubu River catchment was extracted from an existing hydrocensus database that was obtained from the non-governmental organisations that are involved in spring protection in the catchment, namely, Environmental Rural Solutions (ERS), Conservation South Africa (CSA), Lima Rural Development Foundation (LIMA) and World Wide Fund for Nature South Africa (WWF-SA). A hydrocensus is a process that involves gathering information on water features, water supply sources and sources of potential water pollution in a particular site or area (DWAF, 2004). In the present instance, hydrocensus was used as a tool to gather and assess data on spring location, type, condition, and number of dependents on the spring. A sample of the tool is shown in Appendix C, depicting how data are represented within the hydrocensus attribute table. Additionally, training on citizen science tools and ground-truthing exercises for mapping identified springs in the Sibi area was undertaken.

For the Thukela River catchment spatial data analysis, datasets from Okhahlamba Local Municipality and uThukela District Municipality hydrocensus were used to obtain information on spring location, type, condition, and number of dependents on the spring. Due to multiple data captures, pre-processing of the hydrocensus dataset was undertaken where the attribute information was cleaned and standardized for better processing and computing performance. All the geoprocessing and data cleaning was done using Geographic Information System (GIS) software. Attribute information per spring was then spatially represented in a map format to be able to visualize the information spatially/geographically in relation to other land features. Municipal spatial planning tools such as the Integrated Development Plans (IDP) and Spatial Development Plans (SDF), together with national Census data were used to unpack the socio-cultural dynamic within the two local municipalities.

2.3. Approaches to strengthen decision-making support of governance structures

A mixed methods approach was used to collect and analyse qualitative and quantitative data (Ivankova *et al.,* 2007). This design allows for a more comprehensive study of the problem and enables the researchers to compare the results to existing data. Qualitative aspects were engaged with to voice previously unheard groups of groundwater-dependent communities (Ivankova *et al.*, 2007). The method is based on pragmatism choosing the most practical strategy that allows co-learning and co-creation of knowledge. A concurrent Triangulation Strategy was employed (Creswell, 2003) to collect the qualitative and quantitative data simultaneously to compare the findings of the different methods in a quest to produce well-founded conclusions (Creswell, 2003; Ivankova *et al.,* 2007). Due to the nature of the in-depth focus of the study, the researchers gave priority to the qualitative results and used the quantitative results to describe and quantify variables associated with the trends and relationships explored (Creswell, 2003).

Due to restrictions related to the COVID 19 regulations, data was collected in various ways. Combined multiple methods for data collection and triangulation were employed during data collection and analysis to reduce the time and cost required for research (McNall and Foster-Fishman 2007). Data was collected through group discussions during physical and virtual workshops, site visits, observations, and participation in community meetings, as well as online surveys. Ethical considerations included protecting the identity of persons involved in all data gathering processes as prescribed in the ethical clearance certificate granted by the University of Kwa-Zulu Natal (KZN) [*Research Protocol reference HSSREC/00003527/2021*].

2.3.1 Co-development of Innovative Strategies in governance - Principles applied

Co-innovation is defined as the result of networking and interactive learning among a heterogeneous set of actors, such as farmers, input industries, processors, traders, and researchers (Couttes *et al.,* 2017). Organisations create new products, processes by sharing complementary resources, knowledge, and competencies (Bossik, 2002). The study applied the Local Adaptive Capacity Framework adapted from Jones *et al.* (2010) to assess the adaptive capacity of two communities in the uMzimvubu River (Eastern Cape Province) and the Thukela River (KZN Province) catchments. The context of institutions and organisations at various levels, legislation and resource management are vital considerations in improving the adaptive capacity in groundwater dependent communities. Co-development of innovative strategies in governance is context-specific and adaptive, calling for the implementation of co-innovation to be tailored to the particular situation, which could change over time. In this study, the following principles (adapted from Coutts *et al.,* 2007) guided the innovative co-development of these strategies:

i. *Understanding the problem.* The research team engaged in several stakeholder engagement workshops. Following the workshops, an online poll was conducted in which several issues were found and a range of proposed remedies advanced.

ii. *Inclusivity.* The research team invited all relevant stakeholders to engagement/ consultation workshops, including the youth and women from the selected committees. In this way, the research team and the stakeholders worked towards understanding the problem, its causes, and how workable solutions could be developed.

iii. *Shared learning*. To understand the problems, the research team and stakeholders attempted to learn from one another through active listening and being open to new ideas.

iv. *Wider context*. The stakeholder engagements served to outline the broader context of the problem. In this regard, an understanding of the role of the external influence of stakeholders beyond the community was vital. Equally the consideration of the prevailing policy and legislative framework was crucial to the co-development of innovative strategies

in governance.

As the study was focused on the process of co-learning with selected communities and relevant institutions and actors to promote adaptive capacity of rural communities to climate change in the uMzimvubu and Thukela River Catchments, the ideals of the above-mentioned principles were explored through the following Key Questions:

Key Questions:

1. *What vulnerabilities are groundwater-dependent communities exposed to?*
2. *What is the level of awareness both in the communities and within the relevant structures and institutions?*
3. *What governance provisions exist in relevant networks, and what capacity exists to implement adequate groundwater governance?*
4. *What adaptation strategies are in place, and what initiatives can be co-developed (or strengthen) within the institutions of the selected communities of the uMzimvubu and Thukela River Catchments?*
5. *How can these adaptation strategies be scaled up and or scaled down to ensure the strategy's equity, inclusivity, and sustainability?*

2.4 Evaluating the relevance of social-cultural behaviours

To understand the socio-cultural values of springs, other data-gathering processes were undertaken. The processes involved conducting focal group discussions, the use of questionnaires, personal communication, and feedback from involved stakeholders. The approach used to acquire information regarding the socio-cultural behaviours and beliefs was through interactive group sessions during workshops and spring site visits where the community and other role players were engaged on this subject. Specialist input from a Spiritual Healer provided guidance on the appropriate communication methods that are culturally sensitive and do not undermine traditions and customs in the villages.

A questionnaire was used to facilitate the discussions amongst participants. Questions were aligned to the five objectives of the study (Table 2.3).

Table 2.3: *Linkages between project objectives and questions used to guide stakeholder engagements.*

Project objective	**Question posed to stakeholders during engagement sessions**

Objective 1	What is your experience with climate change-related changes in groundwater supply, and what strategies, as well as frameworks, inform your response in ensuring water supply and adaptive capacity in groundwater-dependent communities?
Objective 2	What are the governance structures (formal and informal), institutional capacity and decision-making processes that inform water supply for groundwater-dependent communities? Which role players work on water service delivery and how do you interact with them to ensure a continuous supply of water for groundwater-dependent communities?
Objective 3	What are the available strategies for protecting and rehabilitating springs, and what regulatory instruments ensure appropriate utilisation of springs (at national, regional, and local level)?
Objective 4	What data and information does your institution have on springs in the catchment? Does this information incorporate the condition and use of springs?
Objective 5	What is the socio-cultural significance of springs to communities in the catchment? Has the significance of springs influenced the feelings and perceptions towards restoration of water-related ecological infrastructure in the catchment?

CHAPTER 3: OUTCOMES

3.1 Stakeholder engagement and mapping

The research team engaged with the Environmental and Rural Solutions (ERS) team, as the uMzimvubu Catchment Partnership (UCP) secretariat that is currently working on the Springs protection project, to ascertain current interventions and gauge the synergistic relationship between the work and the research project team. ERS is also championing a range of ecological projects currently under way in the catchment and are appointed by SANBI as the uMzimvubu Catchment Convenors for the Living Catchments project (WRC Project No. K5: 2984). ERS has extensive experience in rural development issues and has been working closely with the local municipality and communities to advance environmental protection plans, including clearing of alien vegetation, promoting sustainable rangeland management, and protecting open springs. This organisation was pivotal in the site visits where a number of open springs were visited, and the project team had the opportunity to interact with community members that are involved in the current and potential spring protection initiatives projects in the Sibi Traditional Authority area. Various partners participated in the spring assessment exercise together with community members from the different villages in the Sibi Traditional Authority area. Other engagements were conducted in different workshops where active UCP members were present and shared their information on springs protection initiatives.

Figure 3.1: *uMzimvubu Catchment Partnership (UCP) Stakeholder Engagement workshop*

The Springs for Life project team also collaborated with the Institute of Natural Resources (INR), the Thukela Catchment Convenors for the Living Catchments project (K5: 2984) who hosted their inception workshop to engage with the different stakeholders in the same platform, this workshop was aimed at introducing the Spring for Life project and team to the catchment stakeholders, identifying and discussing stakeholders roles and responsibilities/ initiatives in the nexus of built-ecological infrastructure.

Figure 3.2: *Thukela Stakeholder Engagement workshop.*

Figure 3.3: *Participants in the stakeholder engagements for the Spring 4 Life Project, in the uMzimvubu Catchment, Eastern Cape (permission to take records was granted by the participants).*

The stakeholders mentioned in Table 3.1 and 3.2 below have been identified as having various levels of interest and/or influence over the open springs in the two catchments. What was not known at this stage was the type of influence they have on the community's adaptive capacities, the number of resources they have, their decision-making powers and the sustainability of their contribution to the community's well-being. All these facets are essential in enhancing the adaptive capacity of communities to climate changes in the water supply of springs.

Table 3.1: *Stakeholders in uMzimvubu Catchment*

Stakeholder	**Interest**	**Influence**
1. Department of Water and Sanitation (DWS)	5	3
2. Ezemvelo KZN Wildlife (Maloti Drakensberg Transfrontier Programme)	5	5
3. EC Department of Economic Development Environmental Affairs and Tourism (EC DEDEAT)	5	3
4. Department of Forestry Fisheries and Environment (DFFE)	5	3
5. Matatiele Local Municipality (MLM)	5	3
6. Alfred Nzo District Municipality (ANDM)	5	5
7. World Wildlife Fund - SA (WWF)	5	5
8. Cooperative Governance and Traditional Affairs (COGTA)	1	5
9. DEFF (Working on Fire)	1	4
10. South Africa National Biodiversity Institute (SANBI)	5	5
11. Department of Agriculture, Land Reform and Rural Development (DALRRD)	5	5

12. Council for Scientific and industrial Research (CSIR)	5	1
13. EC Department of Rural Development and Agrarian Reform (DRDAR)	5	5
14. University of KwaZulu-Natal	5	5
15. Rhodes University (RU)	5	3
16. Environmental and Rural Solutions (ERS)	5	5
17. LIMA Rural Development	5	4
18. Conservation South Africa (CSA)	5	5
19. Traditional Authority (Sibi)	5	5
20. Congress of Traditional Leaders of South Africa - EC (CONTRALESA)	5	5
21. EC Parks and Tourism Agency (ECPTA)	5	1
22. Mehloding Community Trust	1	1

* Five-point scale 1 = very little interest or influence, to 5 = great interest or influence to score each stakeholder.

Table 3.2: *Stakeholders in uThukela Catchment*

Stakeholder	**Interest**	**Influence**
1. Ezemvelo KZN Wildlife (MDTP)	5	5
2. Department of Water and Sanitation (DWS)	5	5
3. KZN Economic Development, Tourism & Environmental Affairs (KZN EDTEA)	5	5
4. Department of Forestry Fisheries and Environment	5	5

(DFFE)		
5. Okhahlamba Local Municipality (OLM)	5	5
6. Uthukela District Municipality (UDM)	5	5
7. World Wildlife Fund - SA (WWF)	5	4
8. Wildlands Conservation Trust	5	5
9. Cooperative Governance and Traditional Affairs (COGTA)	1	5
10. DFFE (Working on Fire)	1	4
11. Traditional Authorities (AmaNgwane)	5	5
12. Traditional Authorities (AmaSwazi)	5	5
13. Traditional Authorities (AmaZizi)	5	5
14. Project Steering Committee (AmaNgwane)	5	1
15. Project Steering Committee (AmaSwazi)	5	1
16. AmaZizi Concerned Citizens	5	1
17. Project Steering Committee (AmaZizi)	5	1
18. South Africa National Biodiversity Institute (SANBI)	5	5
19. Institute of Natural Resources (INR)	5	5
20. Department of Agriculture, Land Reform and Rural Development (DALRRD)	5	5
21. Council for Scientific and industrial Research (CSIR)	5	5
22. KZN Department of Agriculture and Rural	1	5

development (KZN)		

* Five-point scale 1 = very little interest or influence, to 5 = great interest or influence to score each stakeholder.

Stakeholder mapping is an important process that supports stakeholder analysis. Stakeholders were mapped and then grouped or categorise to guide the stakeholder engagement process. Stakeholders were categorised into external or internal to the project. For this project the internal stakeholders are the collaborative partners in the project team (Ezemvelo, CSIR, DALRRD, SANBI and UKZN). Stakeholders were further categorised into government departments (at national and provincial level), local government (district and local municipalities), government agencies/entities (at national and provincial level), academia, research institutions, NGOs as well as communities and Community-Based Organisations for the two respective catchments. Several government department stakeholders at national and provincial level were identified for both catchments. Local government stakeholders were also identified for both catchments at district and local level for the Upper uMzimvubu and Upper Thukela catchments. There were government entities identified at national and provincial level for both catchments. National entities are typically involved in both catchments whereas provincial entities are involved at the level of their own province (and catchment). There is interconnection between academia and research institutions since academic institutions do research whereas not all research is done by academic institutions. There are a number of identified NGOs, some operate at a more local scale and are therefore associated with one of the catchments, whereas generally the NGOs that have a national footprint (such as WWF-SA) have been identified as stakeholders for both catchments. In terms of communities and community-based organisations, there are more stakeholders identified for the Thukela than for the uMzimvubu. It is important to note stakeholder mapping supports stakeholder engagement and this needs to be done early into the project.

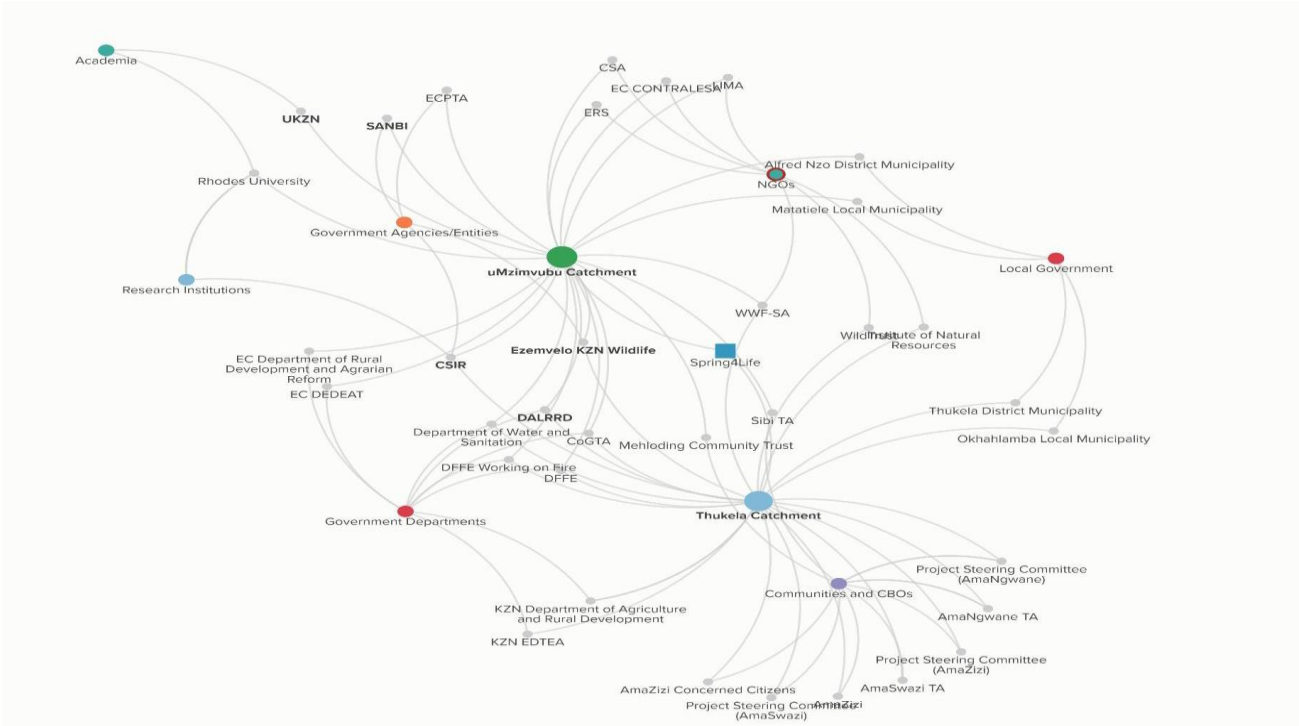

Figure 3.4: *Map of stakeholders in the Thukela and uMzimvubu catchments.*

It is worth noting that stakeholder mapping is not a static process but rather, was a continuous process throughout the project lifespan. Stakeholders refer to organisations (or representatives thereof) who are affected by or have influence by an intervention or activity. Stakeholders are not only those with the loudest voices but also those that are excluded from decision making and planning processes while affected by the decisions made.

According to the mapping exercise (Figure 3.4), there are more stakeholders (organisations) involved and/ or concerned with the use and management of springs in the uMzimvubu than the Thukela catchment. This could be attributed to the fact that uMzimvubu catchment has an already organised stakeholder group (the uMzimvubu Catchment Partnership) which was used as a platform of engagement by the project team. It is more effective and efficient to tap into an existing than creating a new platform for engagement with stakeholders. Existing platforms also enable sustainability and uptake of project recommendations as they continue to exist beyond the project lifespan. The Thukela catchment has more localised platforms of engagements which are not catchment-wide, such as the Bergville Catchment Management Forum. Catchment Management Forums are established by the DWS as non-statutory stakeholder platforms at sub-catchment level to support stakeholder participation in issues associated with catchment management. These stakeholder platforms are convened and coordinated by the DWS regional office/s. Their autonomy is limited than that of catchment platforms which are self-organised stakeholder networks or platforms.

Both catchments have representation from traditional authorities (Figures 3.5 and 3.6). Traditional authorities play an important role in landscape governance in rural areas where the springs are generally located. These traditional authorities and councils fall under the beneficiaries and user group due to them using the spring as either the sole source of water supply or as a supplementary source to boreholes in areas where boreholes are still functioning optimally. This then points to the importance of catchment and ecological infrastructure management for these areas that are not fully serviced by the government.

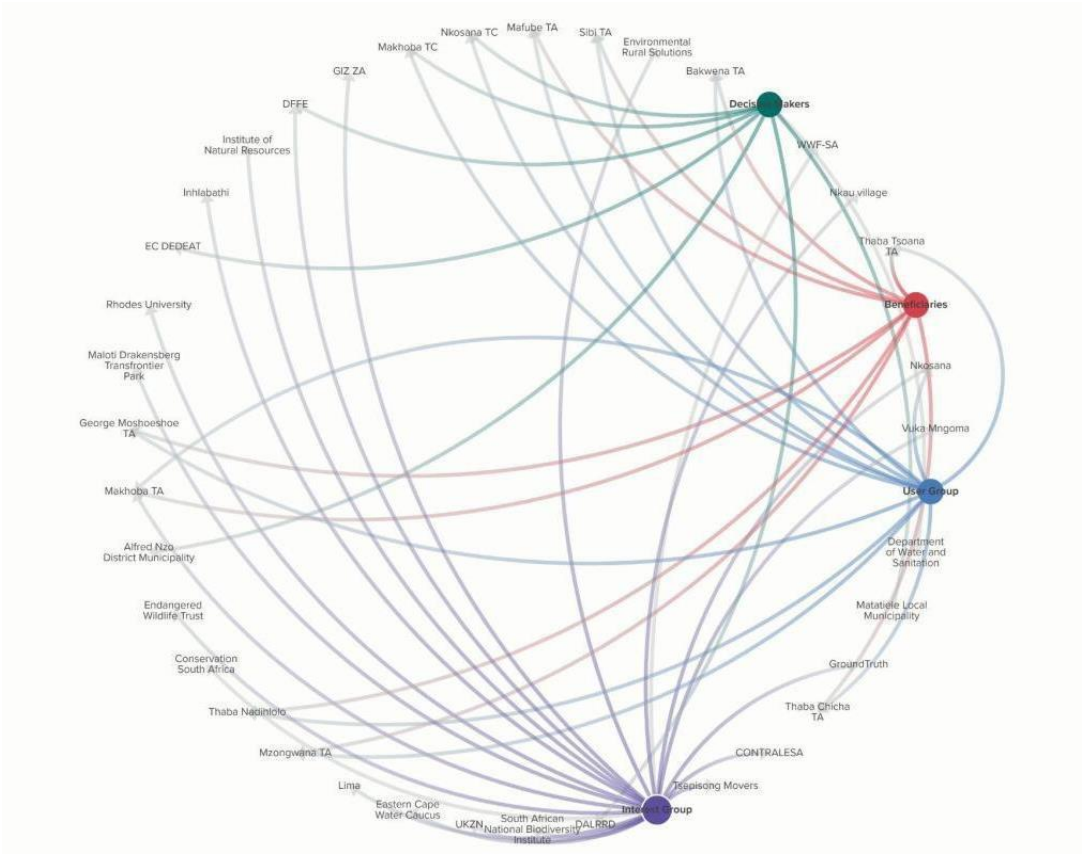

Figure 3.5: *Stakeholder map for the uMzimvubu catchment*

There are various NGOs and research institutions that fall under the interest group due to their contribution either through funding programmes or research projects associated with the management of springs. Government departments at national and provincial level as well as municipalities fall under the decision makers categories as they make decisions through their decision- making roles and responsibilities associated with policies, strategies and plans that impact on spring management.

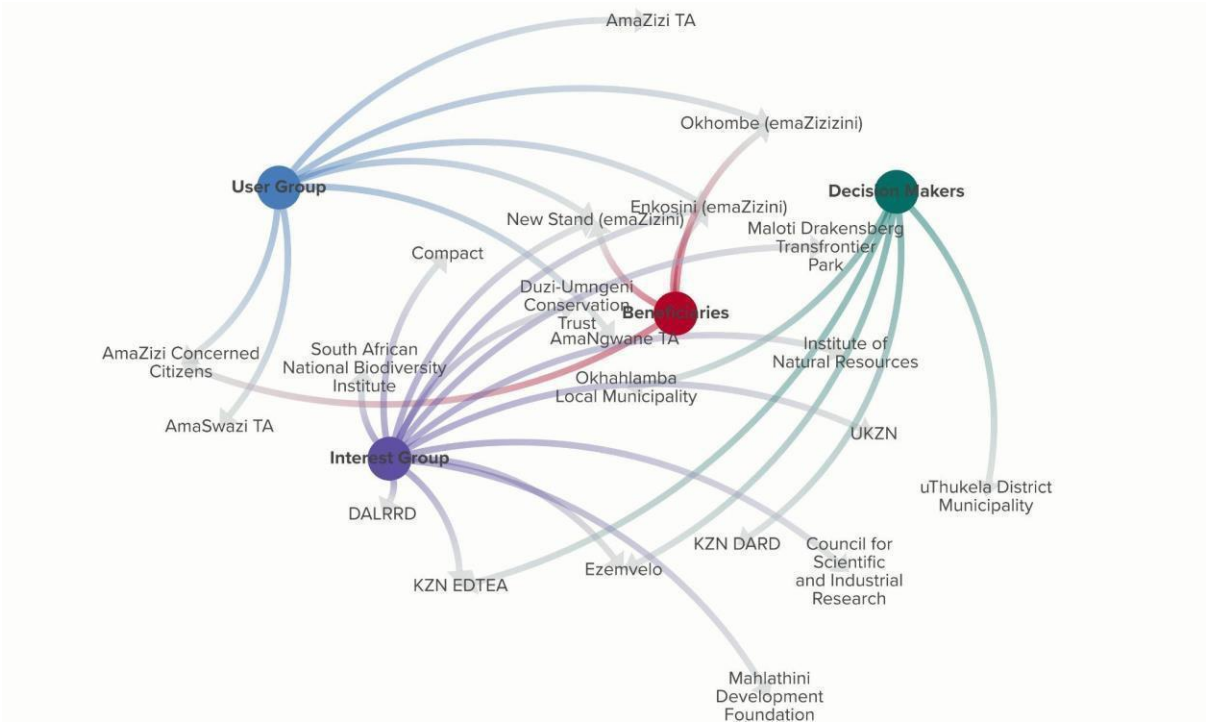

Figure 3.6: *Stakeholder map for the Thukela catchment*

3.2 Spatial analysis

Many communities in South Africa are facing a greater challenge when it comes to accessing clean water for household use and livelihoods. The hardest hit are the rural communities that are on the outskirt or fringes of administrative boundaries. Looking at both the study sites (Matatiele and Okhahlamba Local Municipalities), the rural communities within them are relying on natural resources for provision of goods and services. In terms of water resources, many rural communities within these municipalities use springs as their major source of water provision. These springs are used for multiple purposes, including drinking, washing, livestock and other basic household needs as well as cultural practices. The above challenge is due to the lack of water infrastructure facilities around or within some communities.

3.2.1. Spring location and attributes

Hydrocensus was used as a tool to gather and assess data on spring location, type, condition, and number of dependents on the spring. Hydrocensus data revealed that there are correlations among the attributes relating to the spring location, type and nature, the condition of the springs

as well as how many households are depending on springs for water resources. Visualizing spatially the spring locations, most of the springs are situated in the headwaters of water-related features i.e., rivers and wetlands (Figure 3.7 and 3.8). Looking at the geographical distribution of the springs on the landscape, no pattern is formed however most of them fall within the identified Strategic Water Source Areas. Around these springs, are the number of rural communities or households. Even though both catchments have hydrocensus data, there are gaps in the attributes mapped in the Thukela compared to those in the uMzimvubu River catchment.

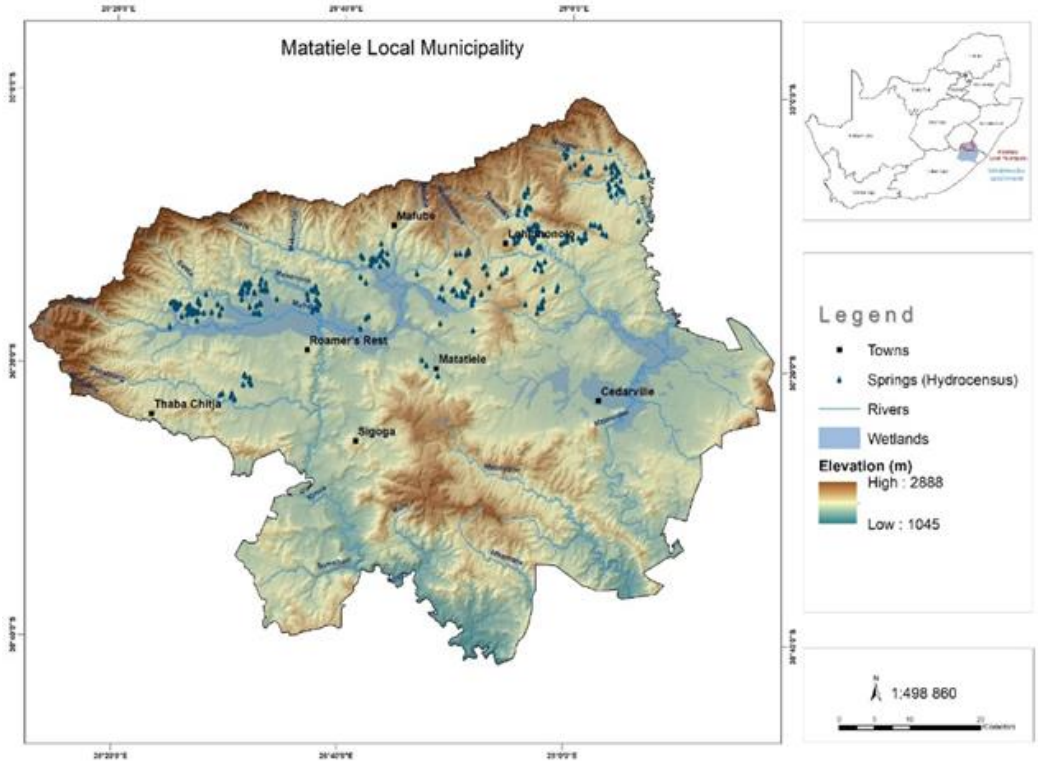

Figure 3.7: *Location of springs in Matatiele Local Municipality (Hydrocensus).*

For the Thukela River catchment spatial data analysis, two datasets were used, one from municipal records (hydrocensus database from Okhahlamba LM) and another from uThukela DM.

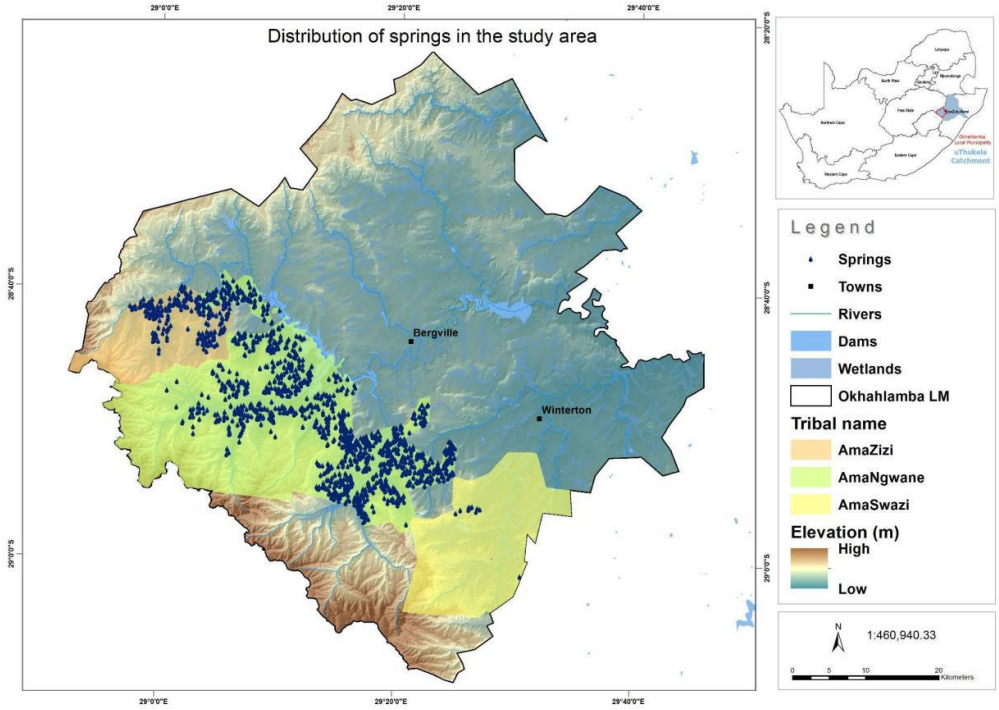

Figure 3.8: *Location of springs in Okhahlamba Local Municipality (Hydrocensus)*

Due to the location of the springs coupled with environmental variables, many springs vary when it comes to "geophysical" attributes.

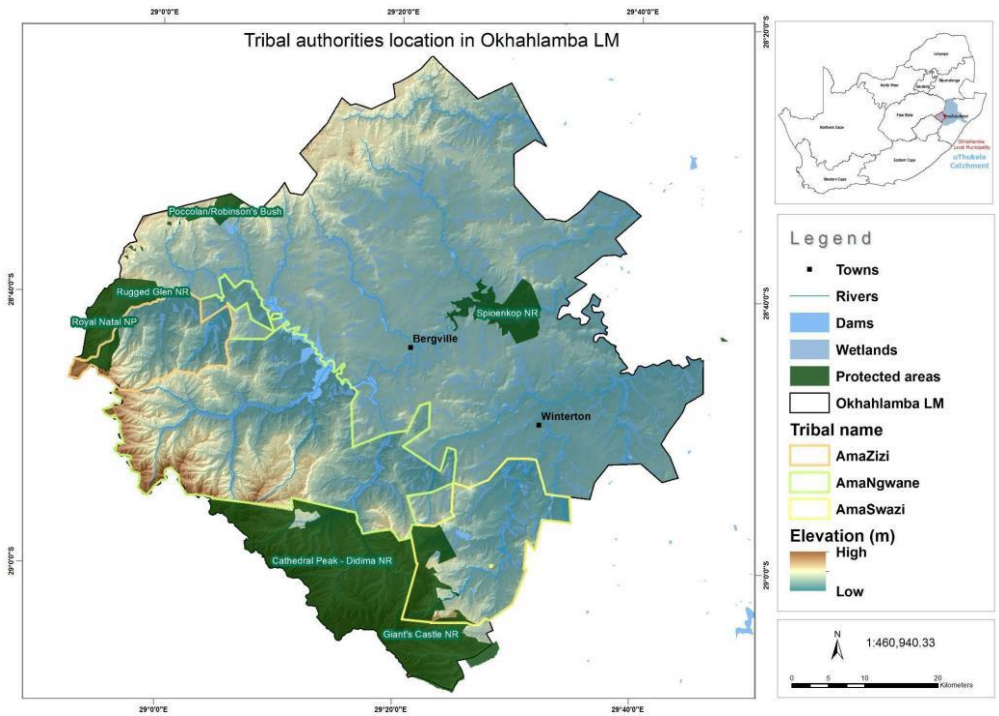

Figure 3.9: *Tribal authorities' location in Okhahlamba LM.*

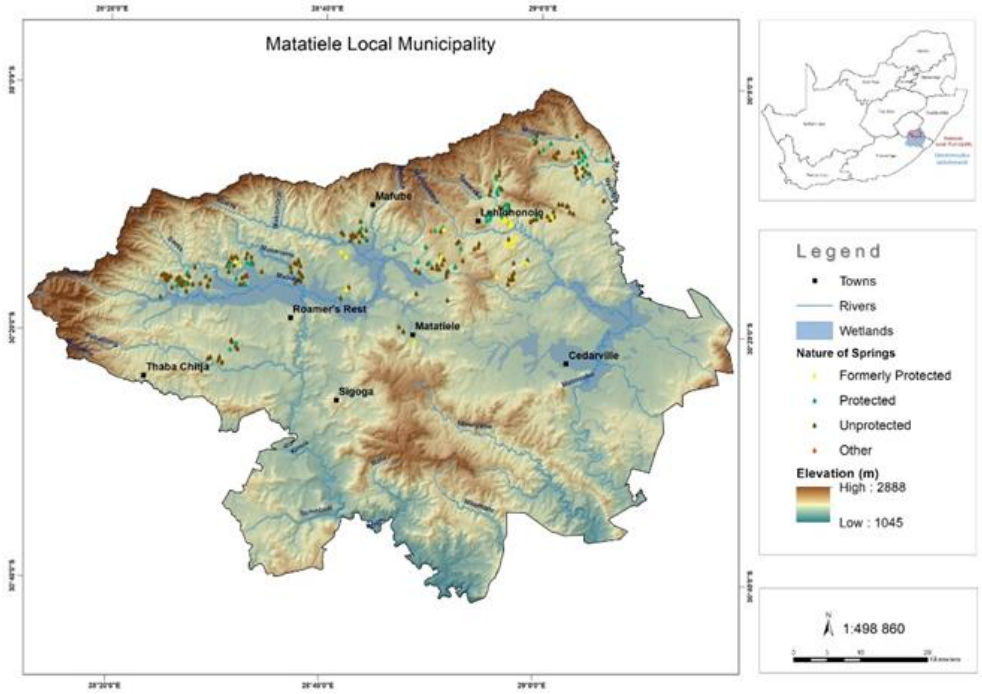

Figure 3.10: *Nature of springs in uMzimvubu catchment.*

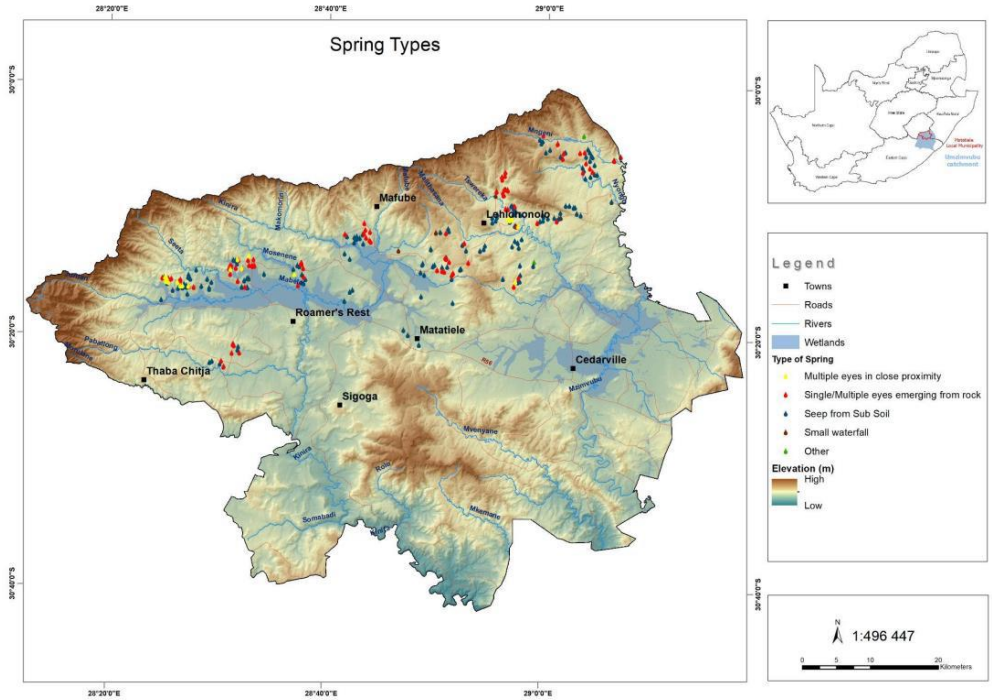

Figure 3.11: *Spring types in the uMzimvubu catchment.*

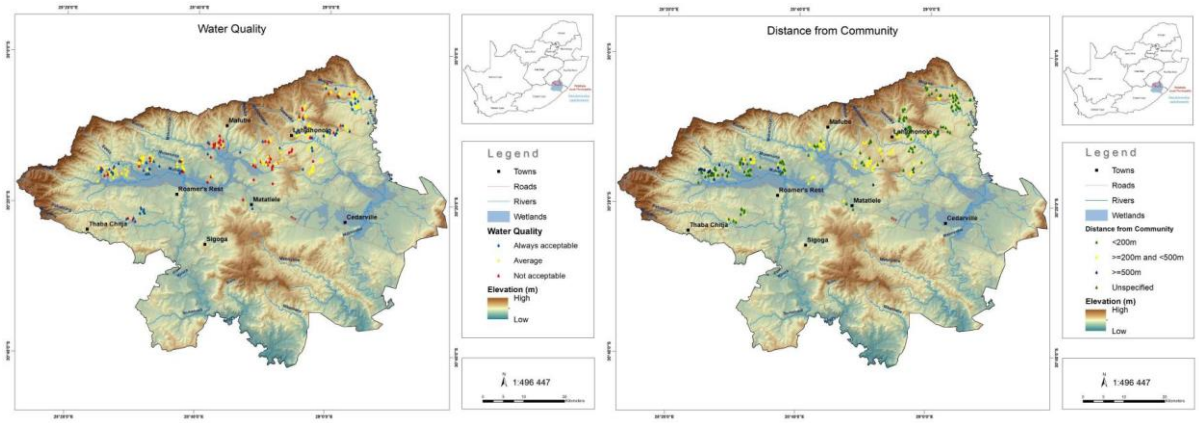

Figure 3.12: *Water quality and distance from community in uMzimvubu.*

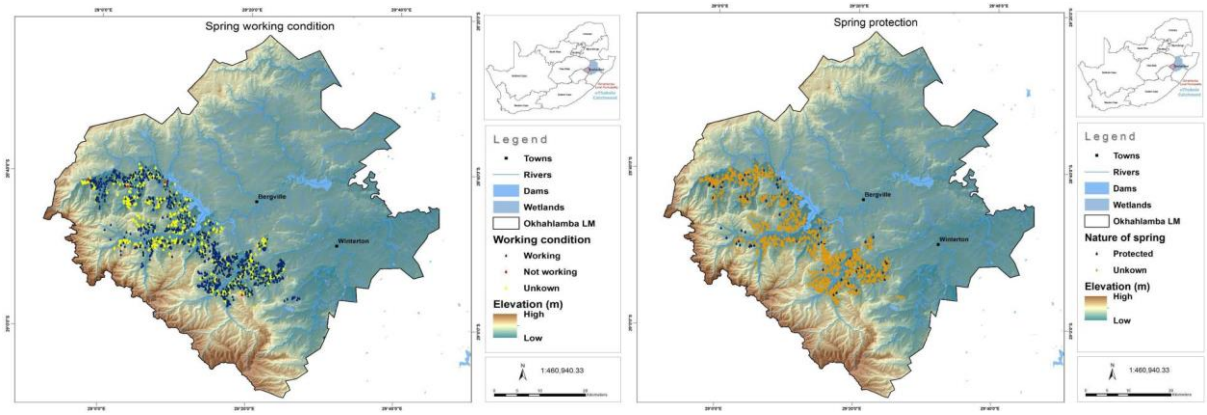

Figure 3.13: *Spring working and protection conditions in the Thukela catchment.*

3.3. Co-development of Innovative Strategies in governance

This section is based on findings from the interviews that were conducted in efforts to understand the strategies for adapting to climate change in groundwater-dependent communities. Section 3.3.1 reports on typologies of vulnerabilities to adaptive capacity in the two catchments. Section 3.3.2 reports on the effectiveness of existing governance provisions and the capacity to implement adequate groundwater governance in the two catchments. Section 3.3.3 reports on local *ad hoc* arrangements developed in the catchment to deal with ground water quality, availability, and protection issues.

3.3.1. Vulnerabilities to adaptive capacity in the two catchments

The National Groundwater Strategy (DWS, 2016) recognises groundwater as a vulnerable resource to be protected. Groundwater development can have critical consequences for streamflow. Change in streamflow has significant implications for available water resources (Asadieh *et al.*, 2016). Low streamflow events usually depict the presence of drought conditions, whilst high streamflow events depict high precipitation events. Thus, streamflow information is important for making informed decisions about water supply requirements, particularly during periods of drought. Using streamflow as a proxy in the current study, has revealed that on average, the Matatiele LM experienced 10 agricultural drought epochs between 1985 and 2020 (Appendix D), with the persistence of agricultural drought varying from one area to the other. This is a concern as climate change projections indicate that the frequency and impact of droughts are likely to increase for many regions of the world (IPCC, 2013). (See Appendix D: Low Streamflow Events - Standardized Streamflow Index (SSI) > 0.8)

The link between land-use and groundwater has long been recognised but has not been widely translated and integrated into policies and practices (GWP, 2014). Land-use exerts a major influence on groundwater in terms of contamination from a wide range of activities and through impacting groundwater recharge processes. The potential negative impacts are enhanced by inadequate knowledge and the unseen nature of groundwater. There is an expectation that groundwater from springs will become increasingly less secured due to a combination of climate change and human activity or human inaction. Adaptive capacity requires a sound understanding of the perceptions of groundwater users and relevant institutions on the vulnerability of groundwater.

Through stakeholder engagements, site visits and online surveys, a range of vulnerabilities of groundwater communities together with the springs/wells were identified. Table 3.3 presents an overview of typologies and vulnerabilities.

Table 3.3: *Typologies of vulnerabilities to adaptive capacity in the uMzimvubu & Thukela River Catchments*

Typology	**Process**	**Low risk**	**Medium risk**	**High risk**
	Drying up due to excessive drought	✓		

Direct Climate-related changes Silting of springs	Silting due to excessive rain			✓
	Inappropriate land use around the eye of the spring/ mouth of the spring		✓	
Indirect climate-related changes Contaminatio n [on-point and off-point]	By animals			✓
	Contamination from leached fertilisers	✓		
	Contamination from household refuse		✓	
	Contamination from human excrement		✓	
	Alien plant invasion	✓		
	Depletion of ground cover due to veld fires		✓	
Low levels of awareness	In the community			✓
	Within local municipalities		✓	
	Within civic structures including traditional leadership		✓	

Adapted from Petersen et al. (2012)

Information from Table 3.3 was analysed to determine the different vulnerabilities that groundwater communities face, as well as the perceived risk level in each case. Data were obtained from 82 households in the catchment through an online survey. The following is a graphical representation and narrative description of the survey's findings.

3.3.2. Direct climate related factors causing vulnerabilities of springs

According to Figure 3.14, silting due to excessive rain was perceived as posing a high risk by more people (37%) than springs drying out as a result of serious drought (28%) or improper land use near the spring's eye or mouth (18%). In fact, most of the respondents rated inappropriate land use near the spring's mouth as a medium risk.

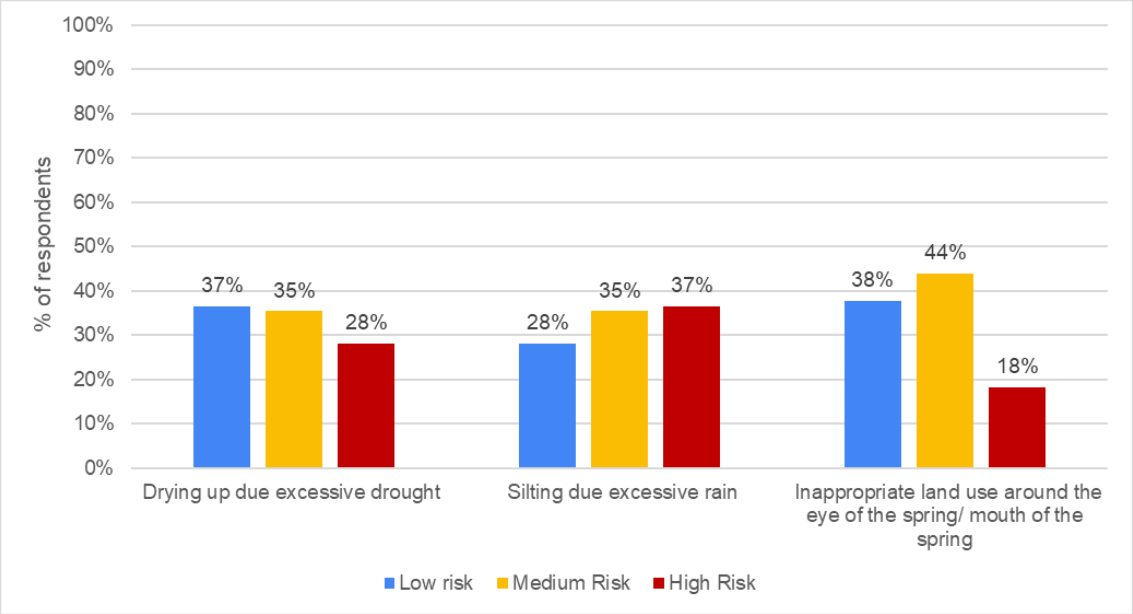

Figure 3.14: *Risk rating of direct climate-related vulnerabilities of springs by online survey participants.*

3.3.3. Indirect climate-related vulnerability factors

With regards to indirect climate-related changes, Figure 3.15 suggests that 52% of people view animals as a high-risk source of contamination compared to other possible sources. It was also noted that contamination from human excrement and household refuse poses a medium risk and is a threat as a water pollutant with serious health consequences. Equally, 38 % of people viewed the depletion/loss of ground cover through veld fires as a matter of concern that poses a medium risk. Alien invasive plants are regarded as the lowest risk point of contamination.

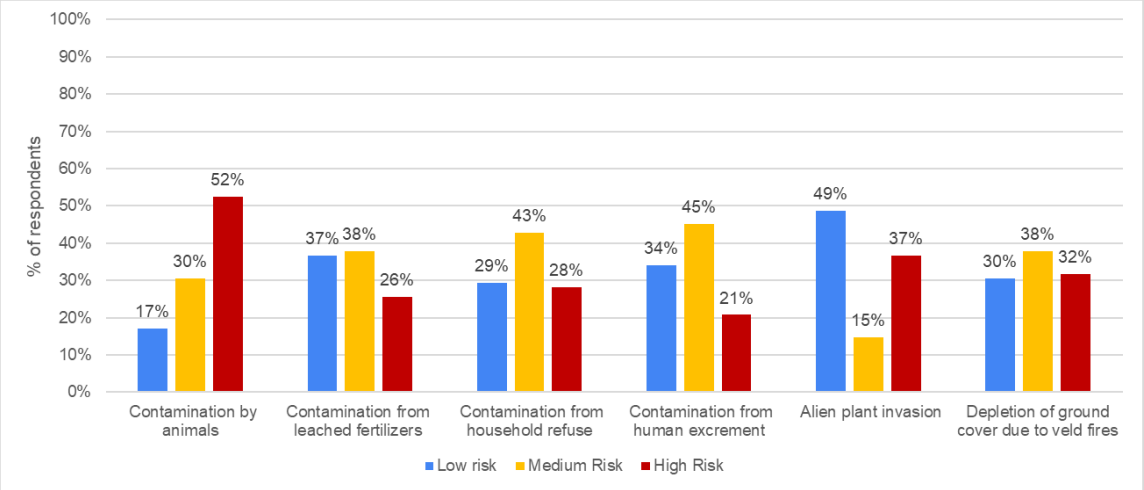

Figure 3.15: *Risk rating of indirect climate-related vulnerability factors by online survey participants.*

3.3.4. Levels of awareness as a high-risk vulnerability

Awareness of the nature and importance of groundwater is crucial for communities to build their adaptive capability, not just as a valued communal resource, but also as a resource whose sustainability is contingent on a range of circumstances. Figure 3.16 shows that while the local municipality and civic structures are aware of the concerns connected with spring vulnerabilities, low levels of knowledge exist within the community near to the springs, posing a considerable risk.

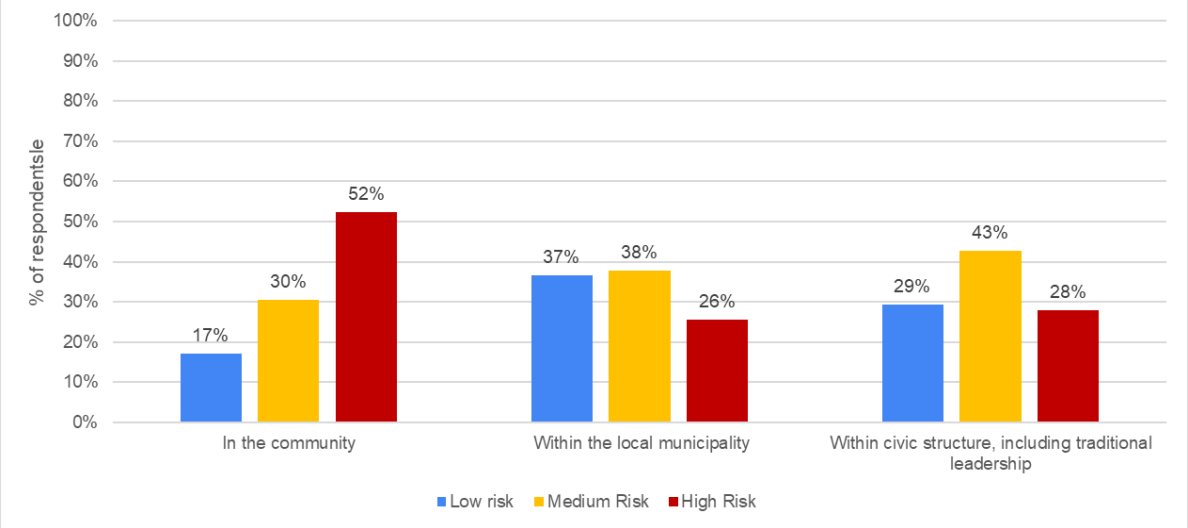

Figure 3.16: *Levels of awareness of spring vulnerability.*

Public participation in groundwater governance refers to a structured framework which encapsulates both the rights of the users of groundwater and their obligations. In this context, the extent to which there were explicit norms, guidelines, and processes in groundwater use and management of springs was explored. Results from the surveys show that most respondents are of the view that there are no clear norms, guidelines, or processes to guide communities and the institutions that service them in the management of springs.

3.4 Spring protection in the selected communities

The study revealed that spring protection structures have been done mostly by communities in partnership with NGOs that operate in the two catchments. Communities view spring protection as an important element to ensure water quality. Spring protection is included in the IDP (2020-2021) of uThukela District Municipality, while the Alfred Nzo District Municipality does not seem to have a groundwater management plan and there is no mention of spring protection in its IDP.

Currently, only 38% and 6% of springs are protected in the uMzimvubu and Thukela catchments, respectively (Figure 3.17(a) and 3.17(b)). The higher level of protection in the uMzimvubu catchment is mostly driven by NGOs working closely with traditional authorities and the communities within which they work. On the other hand, spring protection in the Thukela catchment is largely implemented by the district municipality.

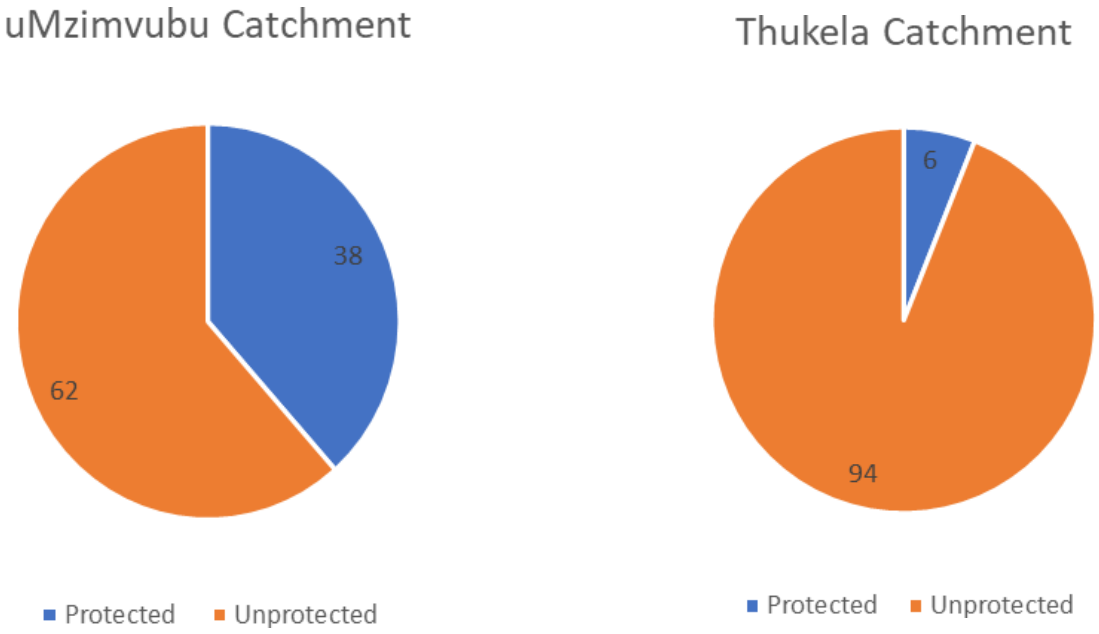

Figure 3.17: *Percentages of protected and unprotected springs in (a) uMzimvubu Catchment and (b) Thukela Catchment.*

Despite the higher incidence of spring protection in the uMzimvubu catchment, most of the respondents rated water quality as not acceptable (Fig 3.18 (a)). In contrast, very few respondents said the same in the Thukela catchment (Fig 3.18 (b)). Instead, the majority rated water quality as average.

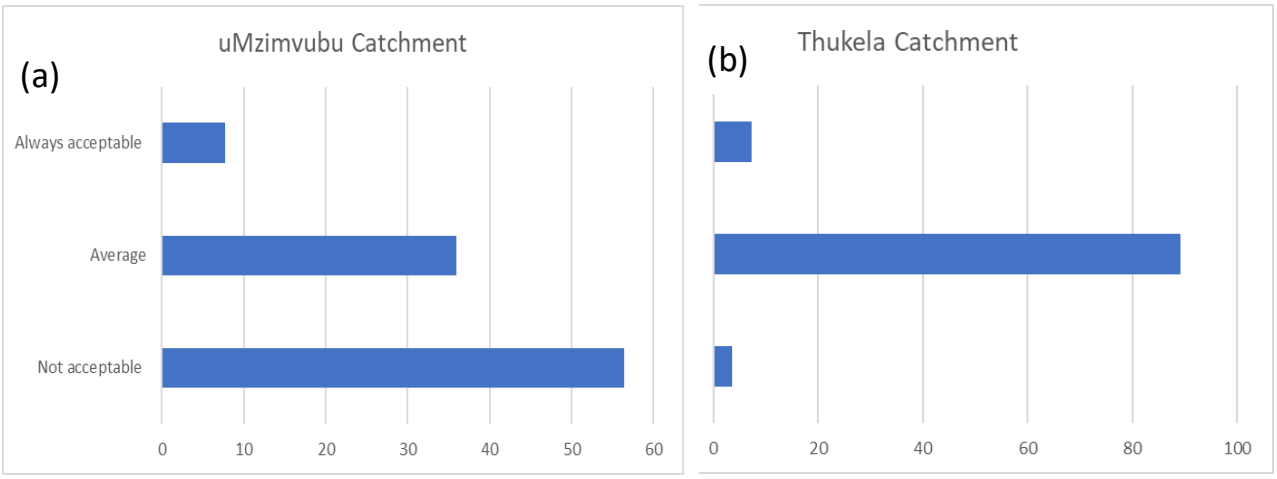

Figure 3.18: *Proportion of respondents' rating of spring water quality in (a) the uMzimvubu and (b) Thukela Catchments.*

3.5 Groundwater governance in the municipal integrated development plans of the two catchments

Following the network map, which identified the role players in groundwater availability, its use and protection, it was necessary to understand what governance provisions were incorporated in municipal plans. This is necessary as it forms the bedrock for developing sound adaptive capacity strategies for climate change and holistic catchment management in support of groundwater-dependent communities. Improving governance and institutional arrangements for groundwater resource management is essential for building adaptive capacity. The findings which follow are based on the Integrated Development Plans of the two districts.

The uThukela District Municipality (UDM) is a Water Services Authority and has the mandate, in terms of the Water Services Act (Act No. 108 0f 1997), to provide water to communities within its jurisdiction. It is evident from the municipal IDP of 2020 – 2021 that the UDM has plans in place for spring protection and upgrading. uThukela District Municipality is actively engaged in groundwater use and protection and their IDP has incorporated the upgrading of springs as a priority activity. The municipality has a specific spring protection and boreholes business plan in place, part of which is to protect and supply water storage to forty- two (42) district wide springs (UDM's IDP 202/21 :413). The IDP also reveals that the Municipality is aware of the long-term

problems related to the degradation of grasslands from increased erosion and declining biodiversity and poor grazing management practices. To this end, the municipality has, within its IDPs, ongoing plans to promote recycling, promote education and awareness campaigns as well as activities for policing of pollution controls. In addition, the District Municipality plans to rehabilitate dongas through gully plugging, gully cutting and planting vegetation. (UDM's IDP 202/21 :214).

The Alfred Nzo District Municipality (ANDM) is both the Water Service Authority (WSA, with full regulation and oversight functions) and the Water Service Provider (WSP, with full delivery functions) in the uMzimvubu catchment. The District Municipality is engaged in major delivery of water supply projects to address backlogs, which are estimated to require R14.6 billion to eradicate, at an average cost per household of R85,000. With the large backlog and steep per capita costs, most of the water supply in rural households comes from standalone schemes using streams, springs, and boreholes. Yet the municipality does not appear to have a groundwater management plan. According to its IPP (2019 – 2020: 313) the reason is that the quality of groundwater might be expensive to treat to the required standards.

While the municipality has operational plans for providing water to communities under its authority, the IDP does not specifically make mention of springs protection, even though there are several interventions that the municipality is involved in. Nonetheless, the ANDM has a District Environmental Forum (DEF) which is convened, and currently chaired by the Department of Forestry, Fisheries and the Environment (DFFE). This forum was established under the provisions of the National Environmental Management Act (NEMA), Act 107 of 1998) and convenes quarterly. There are active representatives from various government sectors, local municipalities, and the civil society. The UCP is a non-statutory platform of network governance for the various stakeholders to discuss catchment management issues in the uMzimvubu catchment. The stakeholder engagement findings indicate that springs are not often seen as a useful alternative source of water in the absence of municipal reticulated water supply. It is critical to investigate how this significant and seemingly neglected resource might be included into the municipality's development plans.

Similarly, and in light of the value that collaborations and partnerships offer to watershed management, it would be helpful to investigate how indigenous structures such as the UCP may collaborate with the municipality to introduce a new perspective on the value of ground water supply.

3.6 Community views on groundwater governance in the two catchments

The views of the communities were that there is a significant loss of traditional governance systems which may be resulting from, among other things, rural-urban migration, creating a

leadership vacuum incapable of protecting common communal resources. This does not appear to be the case in many villages, as one of the community members stated, “we have our own programmes to safeguard the springs; we require water monitors in our villages.” Certain communities already have governing structures in place, such as local traditional platforms as well as local government platforms e.g. municipality IDP forums, and war rooms. The strength of these structures in terms of influencing decisions on spring protection and holistic catchment management appears to be negligible, given there were no indications of current rules and regulations guiding these structures. Discussions with stakeholders highlighted a critical need for extensive community understanding of the threats to springs, the need of changing behaviour to minimise pollution sources, and the significance of community-based structures to manage groundwater and safeguard community springs.

Local government is critical in all aspects of catchment management, but particularly in spring preservation. The participants expressed a need to involve political leaders since they have the authority to affect financial allocations. Although there is an assumption that local government is constrained by a lack of human and financial resources, it continues to serve as a focal point for the development of sound groundwater management methods. Other sectoral departments’ contributions through intergovernmental ties are also significant.

While the participants noted a critical role of local government there is a strong sense of the need to involve the affected communities in discussions in a participatory manner, especially on issues around spring protection. In addition, through discussions with stakeholders, it was advised that ‘further research on groundwater is essential and that the creation of a database on spring related information is needed’. Civil society participates in spring protection and groundwater awareness activities. It is evident that communities including traditional leaders are actively involved in a range of activities to preserve not just the springs but the wider catchment management.

Stakeholder engagement workshops identified that natural resource management is one of the drivers of change in water security affecting the quality and quantity of water from springs in the two catchments. The community perceptions highlighted inadequate grazing practices, invasive alien plants, and waste disposal around the springs as critical issues that need urgent attention. Scott & Le Maître (1998) recommended the development of guidelines and/or expert systems to support policy makers and planners in assessing the importance of groundwater-vegetation interactions and impact on vulnerability. This recommendation is still relevant for both catchments as it can be deduced from this research that there is still a need for harmonisation of policies and strategies that address water and land management issues at community level.

Communities emphasized that good water management means good grassland management. In the upper uMzimvubu catchment, CSA and ERS are working with rural communities to promote rangeland stewardship through signing of Conservation Agreements with communities. This

initiative is supported by the local Traditional Authorities and has had a positive impact on improving spring water quality in some areas. Although the condition of rangelands in the two catchments was not assessed in the current study, communities perceived lack of a community grazing plans, including strategies to control the movement of livestock in the catchment as a serious challenge for spring protection, particularly water quality.

Stakeholders expressed that there is a need for an integrated land and water resource management plan that promotes proper grazing management and clearing of invasive alien plants (wattle) at community level. These views echo the National Groundwater Strategy (2010, 2016) and most recently, the National State of Water Report for South Africa – Summer Season (October 2020 – March 2021), which states that land use has an effect of groundwater vulnerability. Stakeholders, therefore, rated "siltation due to excessive rain" as a higher risk to springs than "drying up due to drought" and "inappropriate land use around the eye/mouth of the spring". Inappropriate land-use does not only lead to degradation of ecological infrastructure, but it can also exacerbate the impacts on climate change on ecological integrity and functioning of natural systems such as groundwater.

3.7 Evaluating the relevance of socio-cultural behaviours

South Africa, because of its social diversity has a myriad of spiritual beliefs and most of them include nature in some form or another. Our country has a majority of black people and they are still highly dependent on indigenous methods of healing which include amongst other things, water. In African spirituality it is believed that every natural resource has a guardian including springs. This means that whenever one attempts to protect or modify a spring, one needs to seek permission and to not destroy the natural spring in the process. The source of the spring needs to remain undisturbed because that is the gift which often can heal when used by spiritual healers. Some of the springs die out because they are unable to breathe as nature intended. This results in the community not getting water as they did before the protection efforts.

After liaising with the community, it was evident that people know the spiritual importance of the springs while they also agree to the need for protection as the springs are their primary source of consumable water. The need for community development in the area as well as a need for employment has made some community members agree to protection ways that end up going against their spiritual sense that a spring must live and breathe. They have resorted to not disclosing some of the springs for fear that the spiritual springs might end up being 'protected' to the community's detriment as said spring water has healing properties. It is important that efforts to preserve and protect do not destroy the resource as that would be counterproductive.

Traditionally, communities had indigenous means of protecting natural resources for the common good. The discussions gave insight into such systems. An elder in one of the stakeholder

engagement workshops revealed that “the belief that a snake resides in each spring is a folklore legend passed down to youngsters to deter them from playing in the springs and contaminating them’’. On the other hand, some people think that the water snake, which is believed to live in and around all springs, is a ‘revered spirit capable of imparting spiritual healing’. Whatever one’s beliefs, springs are revered as sources of water and a life-sustaining commodity, whether physically or spiritually. The physical and spiritual benefits are not mutually incompatible, but mutually reinforcing and necessary for human life.

CHAPTER 4: DISCUSSION

The outcomes of this study indicated inadequacies in existing groundwater governance policy provisions and implementation. Improving governance and institutional arrangements for groundwater resource management is essential for building adaptive capacity. The effectiveness of existing governance provisions and capacity to implement adequate groundwater governance should be strengthened. The social capital at the local and regional governance levels may deliver support and should be harnessed. Understand the dynamics of rural water governance is important for providing guidance towards co-developing strategies for promoting the adaptive capacity of rural communities to climate change.

Communities of the Thukela and uMzimvubu catchments acknowledge the necessity for spring protection and the construction of protective structures around the spring eye because the springs are their primary source of drinking water. However, they are aware that some community members use springs for spiritual and religious purposes. Every natural resource, including springs, is thought to have a guardian in African spirituality. From this perspective, communities expect developers to seek prior consent if the spring is to be protected or modified. Because some communities believe that the spring eye (source) carries a unique gift that, when used by spiritual healers, frequently has the potential to heal. Thus, the spring eye should not be protected by hard structures of construction around it. However, some community members believe that springs dry up once their natural flow is disturbed as they can no longer 'breathe' as nature intended.

4.1. Vulnerabilities to adaptive capacity in uThukela catchment

Contamination: This is caused by human activity as a result of improper domestic waste disposal. Waste management in rural locations is becoming more of a concern as government focuses solid waste management efforts on urban rather than rural communities. The challenge for municipalities is extending solid waste management to rural communities, considering the dispersed nature of rural residences and the difficulty of reaching each household. Without proper solid waste management, residential debris clogs streams and springs, polluting the water and contaminating the springs. Disposable nappies were identified as a significant source of household waste that are deposited around the springs. The communities expressed an urgent need for biodegradable nappies and awareness campaigns on responsible disposal of nappies at community level.

Water quality: There is a general trust within the communities that spring water is clean as it emerges from the eye of the spring and has been used for many years without reports of serious illness. Communities are of the view that natural spring water is of high quality, free of contaminants, bad odour, and illness. However, they concur that once spring water reaches the

accumulation and collecting point, it becomes polluted by external causes such as human activity, environmental variables, or a mix of the two. It is said that in some of the springs, the water has a saline taste. The water quality of the springs has not been confirmed by laboratory testing. It is recognised that there is a need for *awareness* campaigns on spring protection (especially in schools), waste management, donga rehabilitation, and the monitoring of the movement of animals around the springs.

Invasive alien vegetation: This is a common problem in all catchment areas and affects various aspects of ecological infrastructure. There is a high infestation of alien vegetation in the catchments, and this could be affecting the quality and quantity of water flow in our springs in such a manner that some of the springs are no longer perennial. For a long time, the government has been implementing several programmes to clear invasive alien vegetation in South Africa's catchments such as the Working for Water programme. These efforts are perceived not to be yielding desired outcomes in these catchments as they are not directly linked with groundwater management and water security programmes/initiatives. The communities added that "*awareness campaigns on spring protection directed (especially) to schools should ideally be run as a partnership between government and civil society structures"*.

4.2. Vulnerabilities to adaptive capacity in uMzimvubu catchment

Discussions with community members and other stakeholders over numerous engagements revealed the multiplicity of vulnerabilities which categorised as follows:

Water quantity: Climate change has resulted in high temperatures and high rainfall variability with frequent occurrences of short-lived low rainfall episodes reported in some areas in these catchments. It is suspected that there is high evaporation and little time for groundwater recharge, and this has resulted in reduction in spring water quantity and drying out of springs in some areas.

Spring protection: Since some of the springs are not protected, people are forced to use the same water as livestock. As a result, it was reported that some of the springs have poor water quality. The protection of springs is usually initiated by the Traditional Authority who then speaks to the municipality. However, the issues that are getting addressed as well as the reforms do not end up in the Integrated Development Plans (IDPs). In this regard, the communities are now advising them on the practical solutions on spring protection initiatives that are currently spearheaded by local NGOs. The communities are also encouraging the municipality to form partnerships with the different active stakeholders and collaborate to advance spring protection at local level.

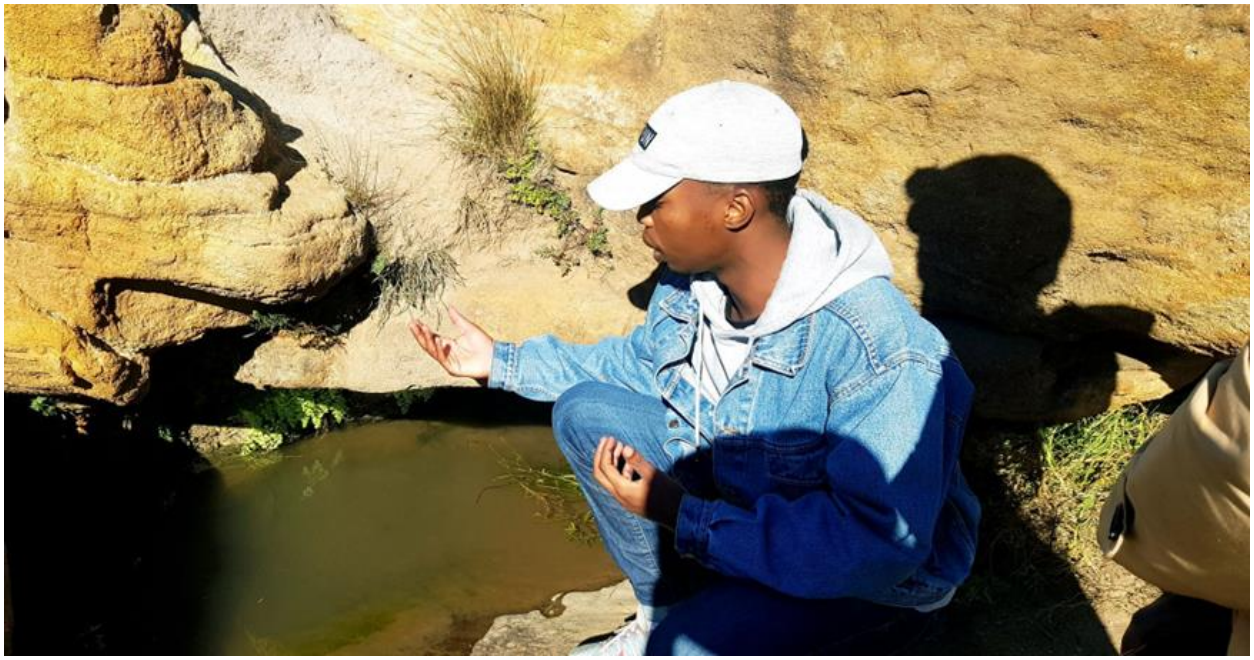

Figure 19: *Site visits KwaSibi, Matatiele, Eastern Cape.*

Participants are aware of the available strategies for protecting and rehabilitating springs, and what regulatory instruments ensure appropriate utilization of springs such as the Spring Protection Guide and Toolkit as well as the Veld Sanitation Guide.

Abstraction for agricultural purposes: Most farmers are dependent on groundwater for irrigation and the over abstraction is noticeably affecting groundwater. During dry seasons, springs produce less water, and it gets worse as agricultural activities expand.

Information and data management: Communities feel that there is available information on springs but is fairly new and needs to be refined and structured in a way that is user-friendly. They expressed the need to have support from research institutions to guide how the information needs to be collected so it can be shared with people. Another aspect that was mentioned was around the social and cultural values of springs which communities are aware of. However, there are rules in place on how the community should use those springs associated with cultural values. There are springs that are only used by traditional healers and those for general use.

Figure 20: *Participants in the stakeholder engagements for the Spring 4 Life Project at Conservation South Africa (CSA) Offices, Matatiele, Eastern Cape on 22nd February 2022 (permission to take records was granted by the participants).*

4.3. Approaches to strengthen decision-making support of governance structures

4.3.1. Emerging themes

The Department of Water and Sanitation has a well-developed National Groundwater Strategy. This lays a solid platform for enhancing rural communities' adaptive ability to climate change in groundwater-dependent households. In response to stakeholder discussions and online survey findings, the research team worked continuously and interacted with stakeholders to co-develop strategies that align existing norms and guidelines with available knowledge.

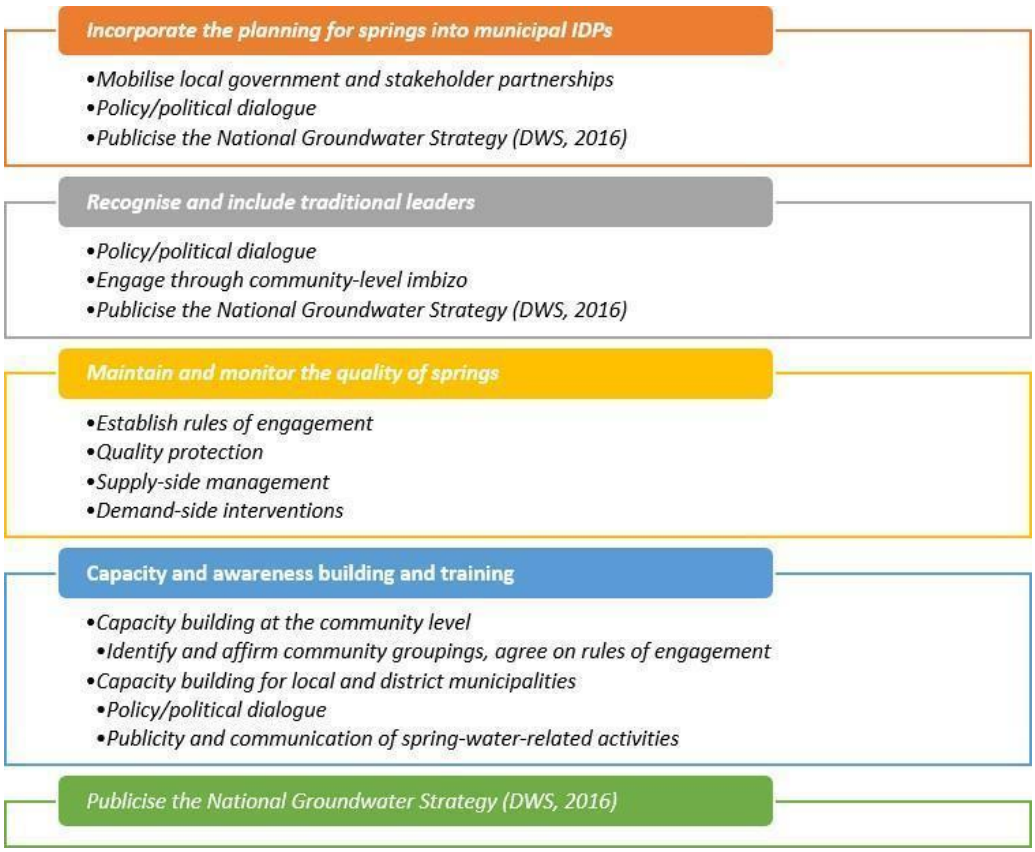

Figure 21: *Summary of conceptual framework for co-developed innovative strategies in the governance of groundwater.*

The NORAD toolbox for spring water protection was one example, but it needed to be adapted to align with the study's findings. Additionally, the following themes were identified and anticipated to strengthen the development of innovative strategies:

1. Consolidating government and non-governmental stakeholder commitments. This research has demonstrated that diverse stakeholders possess distinct abilities and talents, and that joint efforts and partnership structures will significantly boost groundwater management and governance.

2. There is a need to ensure greater involvement of municipalities while ensuring a community voice in water security and supply issues. This requires that the different role players vigorously promote co-development and co-creation of adaptive capacity strategies by employing a combination of bottom-up and top-down approaches to engage groundwater-dependent communities with other stakeholders. A key question in this regard would be: “What and how do we plan and for and with who?”

3. A hybrid approach that incorporates the hierarchical governance style of government and the informal network governance style of catchment partnership (such as the UCP) should be

encouraged to promote the participation of local communities in decision making on groundwater security matters.

4. The study sites are on communal land and under traditional land ownership. Therefore, the role of traditional leaders should not be overlooked. Equally, the voice of the communities, particularly that of women as the primary beneficiaries, ought to be heard. In addition, civil society organisations have shown an interest in groundwater management. Their continued engagement and support are encouraged.

5. Groundwater management plans that reflect the existing complementarity of built infrastructure (in the form of boreholes) and ecological infrastructure (springs) should be developed for these areas which are highly dependent on groundwater supply.

6. Capacity building and awareness campaigns should involve community structures, traditional leaders, civil society structures, local government, and schools. Quantitative and qualitative monitoring of springs using available citizen science tools and effective management of information should incorporate the cultural and spiritual aspects of springs.

7. The management of groundwater and springs is hampered by resource and capacity constraints, as well as inefficient catchment management and governance. Learning exchanges between the two catchments (uMzimvubu and uThukela catchments) could facilitate sharing of information, lessons, and experiences.

8. It is critical to understand and engage with the political context to conserve springs and manage groundwater. Political support could bring value to groundwater management and spring conservation activities. This may be improved by the involvement of catchment partnerships in municipal planning procedures, as well as through community education and capacity building (through various learning platforms)

9. Advisory and support services to help communities in adopting groundwater protection programmes should be provided.

10. Incorporating indigenous knowledge into catchment management could promote understanding of socio-cultural benefits derived from springs as important ecological infrastructure in the communities.

11. Adoption of a catchment approach to invasive alien plant clearing and grazing management.

12. Collaboration for development of innovative waste management practices between municipalities and rural households.

CHAPTER 5: KNOWLEDGE DISSEMINATION PLAN

The strategy for the dissemination of knowledge from this work will include presenting the findings at district municipality environmental forums for both Alfred Nzo District Municipality (ANDM) and Uthukela District Municipality (UDM), especially around the explicit recognition of springs in municipal IDPs (e.g., setting aside budgets to improve management of springs and provide better access to clean water for rural communities). To strengthen the resolve to integrate the recommendations into municipal IDPs, engagements with the local councillors and the traditional leadership at the War Room, a multidisciplinary platform led by the local councillors, are also planned.

It will be important to engage, especially with the district municipalities and DWS, to develop a programme of action based on the recommendations coming out of this study. Amongst other priorities, the programme of action must prioritise development of spring management plans that clarify roles and responsibilities through participatory engagements with the communities and other stakeholders. Importantly, this programme of action, must be community focused to ensure that the voice of the community is not undermined.

Through collaboration with partners, as well as other relevant municipal and civic forums, possible sources of funding for implementing the spring management plans should be explored.

Lastly, as part of the dissemination plan, a policy brief; a newspaper article; informative flyers; and an academic publication will be developed from the outcomes of this research.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

South Africa has enough legal provisions for natural resource management, however research has revealed that there are insufficient institutional frameworks and operational capacity to put these provisions into practice. Although springs are widely used for household water in the research sites, attention still needs to be paid to administrative processes related to procedures to safeguard springs, monitor their quality, or establish community standards for their use. Participatory governance processes could assist in ensuring accountability by both governance institutions and water resource users. Sustainable groundwater governance could benefit from co-development of innovative strategies to take care of springs in spring-reliant communities sustainably. There is an emphasis on organisational change (Kilelu *et al.*, 2013), where knowledge and innovation are "co-produced" by many stakeholders; researchers become part of a broader network of actors, and innovation is an emergent property of their interaction. Because several organisations are involved, collaborative governance is vital as it ensures coordination and sets clear rules of engagement and appropriate sharing of resources.

Advocacy-based cooperative governance among the network of partners was one of the predicted outcomes of this research. The study drew on Kulkarni *et al.* (2000)'s concept of groundwater governance which considers those political, social, economic, and administrative systems that specifically strive to create and manage groundwater resources at various levels of society. Understanding the network of stakeholders interested in groundwater management and spring protection was thus essential to the study. Through stakeholder mapping exercises, the research shows that it is crucial to clarify the division of labour among partners and stakeholders, including local people's involvement in water security decisions.

The study investigated current systems for responsive decision-making about the capacity of communities to adapt to the effects of climate change on groundwater, drawing on collaborative and learning-based engagements with crucial actors. Although there is no one-size-fits-all governance system, it is evident that a system that comprises of institutions and organisations and their components, including networks, policies, principles, and practices, is crucial for sound groundwater governance.

Stakeholder engagements revealed that collaborative governance can influence strategies and frameworks for adaptation to climate change in groundwater-dependent communities. Plans for groundwater governance, specifically springs, are loosely incorporated into formal processes, if at all. Particularly noteworthy was the absence of strategies for spring protection measures in municipal IDPs. As such, when spring protection structures are constructed, there are no clear rules of engagement or roles and responsibilities related to monitoring the infrastructure. Yet the maintenance and monitoring of the spring head for water quantity and quality is essential, as is the long-term care of the constructions around the springs. Incorporation of spring protection

plans in their IDPs will assist in formalising groundwater governance and ensure representative participation of ward committees, izimbizo, and the annual reviews of municipal IDPs. A systematic participatory approach that outlines participants' rights and obligations must be used to facilitate stakeholder engagement. Public participation in the governance of groundwater could ensure that clear norms, guidelines, and processes are in place for spring-dependent communities. A participatory approach could also ensure that social-cultural aspects and beliefs are considered in managing and maintaining ecological infrastructure and protection of the springs.

Recognising and involving traditional leaders in maintaining and monitoring spring quality is considered crucial. Further, a strategy to ensure that community members are given the appropriate information about the characteristics of an ideal spring was considered essential. If community members are given the relevant information about the characteristics of groundwater and understand how groundwater is polluted, if they are made aware that groundwater is a limited resource that can be impacted if not adequately managed, they will be sufficiently motivated to act on this information to manage and protect their groundwater.

Water is represented in all myths, stories, rituals, and religious and spiritual traditions worldwide. Water has been essential to the fertility of fields and the productivity of African communities ever since the earliest African civilisations. Springs provide valuable social and cultural services, and communities have developed traditional systems of governance to preserve and manage them. Both eastern and western religions use water in their rituals because it represents the world of the spirits and has a special place in many religious rites. Waterfalls, rivers, and springs have magical properties in African spirituality (Menye, 2022). As such, it is recommended that these water resources be approached with respect, and through following the required cultural processes of accessing and use of those water resources as they are believed to be sacred. In many spiritual contexts, it is customary to sprinkle water over altars at the start of every ceremony to call the underworld's spirits. Additionally, each type of water—rain, river, spring, pond, lake, sea, water cupped in a tree hollow, dew—is endowed with a unique significance (Tounouga & Brock, 2003).

There is underlying respect for the spiritual value of springs that is embedded in the indigenous knowledge systems of communities. Communities can distinguish between springs that provide spiritual services for exclusive use by traditional healers and those for household and livelihood purposes. Spring protection mechanisms may interfere with therapeutic and spiritual healing properties of water, as such some communities have resorted to keeping location of some of the springs a secret out of concern that the community may suffer because of the spiritual springs being "protected." The engineering design of spring protection needs to consider ecological and socio-cultural aspects of the spring. Protection of springs by engineering methods, should therefore not undermine the goal of achieving harmony between humans and nature.

Engagement with local structures to harness indigenous knowledge including spiritual healers is necessary to balance the water resource protection and water service delivery.

Groundwater management is generally under-capacitated in terms of knowledge and skills compared to surface water in South Africa. This then poses a challenge for the management of groundwater resources such as springs. Most rural communities do not receive water related service delivery and therefore rely on water supply directly from natural water resources. This reliance on natural ecosystems calls for functional ecological infrastructure that can deliver adequate water of good quality to support people's livelihoods. Effective and efficient management of ecological infrastructure can assist such vulnerable communities in adapting to climate change related disasters such as droughts.

It cannot be overstated how vital local and district municipalities are to groundwater governance. They are constitutionally mandated to ensure water supply to communities and have the institutional and resource capabilities to do so. That said, the critical role that NGOs are playing in spring protection within the two catchments is invaluable. The work of NGOs in spring protection is valuable and evident, given their ability to mobilise resources and focus on specific communities. However, the NGOs lack the resources to upscale their activities in the two catchments. A concerted effort by policymakers and the Water Research Commission to identify such NGOs and offer them support in the form of resources and relevant infrastructure is recommended.

In the absence of reticulated water, which many rural municipalities can hardly afford, springs from groundwater will remain a crucial source of water supply for many rural households. The research team found that groundwater supply systems that are properly maintained and safeguarded consistently deliver water of high quality to satisfy household needs. While uThukela District Municipality (UDM) has incorporated spring protection and upgrading in its IDPs, it is not so much the case with ANDM. The incorporation of spring protection in municipal IDPs is not consistently applied and municipalities in both catchments lack clear guidelines on how to manage and monitor the condition and water quality of the springs.

Local NGOs with funding from abroad and from local municipalities have mainly supported hydrocensuses in the two catchments. While this forms a critical baseline database, we advise that more research be conducted to determine the microbiological and physico-chemical quality. We suggest that municipalities, as water service authorities, ought to institutionalise the identification of springs, their protection and water quality monitoring into municipal IDPs. This way, groundwater projects will be prioritised based on factors such as critical need and anticipated socio-economic benefit– rather than on an ad hoc, political or crisis-driven approach.

Protecting springs and regularly monitoring their quality can be done through institutionalised and ongoing coordination of intergovernmental budgeting adopted in the IDPs and budgeting processes of municipalities. In this regard, municipalities should focus skills training, capacity building, technical support, planning and facilitation of groundwater related project implementation. Lastly, consensus on community responsibilities can be negotiated though traditional authorities with the objective of maximising community involvement and the responsibility for operation of groundwater schemes.

The utilisation of groundwater in communal land systems in South Africa has received scant research. Further study is needed to understand better other dynamics connected to the use of springs and their protection in a changing climate. Other areas of research could focus on generating quantitative data on rural households' dependence on groundwater and establishing the water quality of the springs, which has not been confirmed by laboratory testing in this study; exploring the role of African Spirituality in protecting the ecological integrity of springs; and a study on environmental-friendly rural waste management practices.

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APPENDICES

Appendix A: Policy and legislation relevant to ecological infrastructure and water security (adapted from Jewitt *et al.* 2015)

Legislation	Strategic Intent and Key Points
Constitution of the Republic of South Africa	The Constitution is the foundation of all law in South Africa. All laws must be consistent with the Constitution. Section 24 provides for the right to an environment that is not harmful to health or wellbeing. Obligation imposed on the State to protect the environment for the benefit of present and future generations, to: · Prevent pollution and ecological degradation · Promote conservation · Secure ecologically sustainable development
Conservation of Agricultural Resource Act (Act 43 of 1983 - CARA)	CARA governs agricultural resources and their conservation. Prescribes compulsory control measures for: · Maintenance of the production potential of agricultural land · Combating and prevention of soil erosion · Prevention of the weakening or destruction of water sources · Protection of vegetation; and · Combating of weeds and invader plants.

Local Government Municipal Systems Act (No 32 of 2000)	Provides the fundamental principles, mechanisms, and processes necessary for municipalities to ensure access to basic services such as water and sanitation. Requires that municipalities: promote a safe and healthy environment in the municipality; strive to ensure that municipal services are provided to local communities in a financially and environmentally sustainable manner; and encourage the involvement of the local community.
Intergovernmental Relations Framework Act 13 of 2005	Makes provision for the establishment of a framework for the national, provincial, and local government to promote and facilitate intergovernmental relations. Although the three spheres of government at national, provincial, and local are quite distinctive, they are interdependent, interconnected, and interrelated.
National Environmental Management Act (Act 107 of 1998 - NEMA)	Framework legislation that gives effect to Section 24 of the Constitution "for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment". NEMA gives powers to the national Minister of Environmental Affairs to identify activities which require environmental authorisation from the competent authority. Also empowers the minster to identify geographical areas in which specified activities may not commence without environmental authorization. Allows for regulations to monitor compliance with environmental authorisations.

National Environmental Management Biodiversity Act (Act 10 of 2004)	Provides for the management and conservation of South Africa's biodiversity; sustainable use of biological resources; equitable sharing of benefits from indigenous biological resources. Requires the Minister to identify and implement plans for the protection of Critically Endangered, Endangered and Vulnerable Ecosystems as well as endangered species. The Minister must prepare and adopt a National Biodiversity Framework, to identify priority areas for conservation; develop integrated, coordinated, and uniform approaches to biodiversity management in protected areas.
National Environmental Management Act Protected Areas Act (Act 57 of 2003)	Provides for the protection and conservation of ecological viable areas representative of South Africa's biological diversity and its natural land- and seascapes, for their establishment and management.

National Water Act (Act 36 of 1998 - NWA)	Places the country's water resources in the hands of National Government as custodian and trustee to manage resources in the public interest. The NWA allows for: · Water management strategies at a national and catchment level · Protection of water resources (including reserve determination and pollution precautions) · Use of water resources (including the issue of licenses and authorisations) · The establishment of institutions/structures such as WUAs, catchment management agencies (CMAs) and advisory committees · Monitoring of water resources and availability of information related to water resources As an instrument of the NWA, the NWRS aims to ensure that water is used and managed to support equitable and sustainable social and economic transformation and development. In so doing the NWRS recognizes in Chapter five the importance of ecological infrastructure. The NWRS approach is underpinned by the Water for Growth and Development Framework that was developed in 2009. Key financial aspects of the NWRS are given effect via the Pricing Strategy which sets out the financial framework against which charges are set for water use and for the development of infrastructure.

Water Services Act (Act 108 of 1997)	Provide for the right of access to basic water supply and the right to basic sanitation necessary to secure sufficient water and an environment not harmful to human health or well-being. The Water Services Act allows for: · the setting of national standards and norms and standards for tariffs in respect of water services · the preparation and adoption of water services development plans by water services authorities · a regulatory framework for water services institutions and water services intermediaries · the establishment and disestablishment of water boards and water services committees and their duties and powers · the monitoring of water services and intervention by the Minister or by the relevant Province · financial assistance to water services institutions · the gathering of information in a national information system and the distribution of that information · the accountability of water services providers · the promotion of effective water resource management and conservation This is supported by the Strategic Framework for Water Services (DWAF, 2003) that put forward a vision for the water services sector in South Africa for the next ten years, and set out the framework to enable the achievement of the sector vision.

Appendix B: Questionnaires used to engage stakeholders to gather information pertaining to springs.

Purpose of the research

Promoting the adaptive capacity of rural communities to climate change through holistic catchment management: A Case Study of ground-water dependent communities in two catchments

Objectives

One of the objectives of this study is "to strengthen institutional capacity and decision-making support of governance structures" and "to evaluate the relevance of social-cultural behaviours including feelings and perceptions that influence the dependency to and restoration of ecological infrastructure"

Ethics

All information gathered by this survey will be held in strict confidence. Under no circumstance will the Research Team disclose any information on or identifiable with individual. The information submitted will be disseminated only in aggregates and used for statistical purposes. We will not publish, release, or disclose any information in a form that reveals an individual's identity.

A. Demographic information

Province	
District	
Village	

B. About you (Cross or Tick Relevant Box)

Gender of respondent	**Male**			**Female**			
Age group	≥ **60**		**59 - 35**		**34 – 18**		≤ **18**	
Organisation/ Body	**Community member**						
	Traditional Authority						

SPRING 4 LIFE QUESTIONNAIRE

	NGO	
	Government	
	Other	

C. About Spring Water Related Issues

Spring usage (Social-Cultural)	**Drinking & cooking**					
	Laundry (washing clothes)					
	Livestock					
	Gardening					
	Spiritual					
	Other…….					
What structures exist for spring water discussions?	**Community engagement meetings**					
	Traditional council meeting					
	UCP					
	Municipal meetings					
	Other….					
How often do you participate in these structures?	**Weekly**		**Bi-weekly**		**Monthly**	
	Other…….					
	Community leaders					

Who leads these conversations?	**Traditional authority**	
	Local NGO'	
	Local government	
	Other….	

Is the protection of springs part of the conversations?	**Yes**		**No**		**Maybe**	
How do I protect my springs at an individual level?						
What do I appreciate about spring protection						

D. Challenges and Recommendations

What are your three main challenges?

(i)_____

(ii) _____

(iii) _____

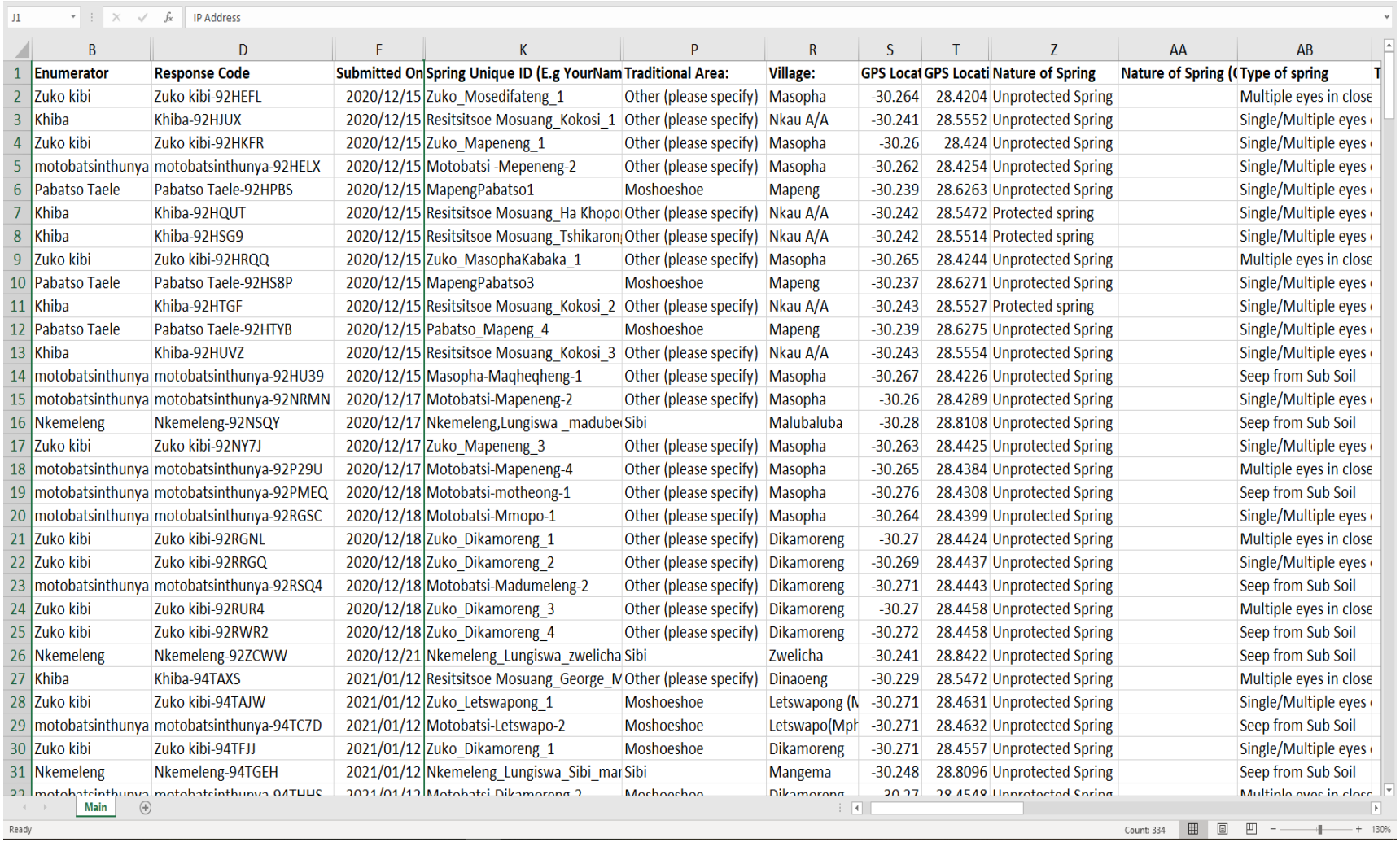
What are your three recommendations on springs rehabilitation and protection?

(i)_____

(ii) _____

(iii) _____

Appendix C: A tool depicting how data are represented within the hydrocensus attribute table.



J1 | IP Address

	B	D	F	K	P	R	S	T	Z	AA	AB
1	**Enumerator**	**Response Code**	**Submitted On**	**Spring Unique ID (E.g YourNam**	**Traditional Area:**	**Village:**	**GPS Locat**	**GPS Locati**	**Nature of Spring**	**Nature of Spring (**	**Type of spring**
2	Zuko kibi	Zuko kibi-92HEFL	2020/12/15	Zuko_Mosedifateng_1	Other (please specify)	Masopha	-30.264	28.4204	Unprotected Spring		Multiple eyes in close
3	Khiba	Khiba-92HJUX	2020/12/15	Resitsitsoe Mosuang_Kokosi_1	Other (please specify)	Nkau A/A	-30.241	28.5552	Unprotected Spring		Single/Multiple eyes
4	Zuko kibi	Zuko kibi-92HKFR	2020/12/15	Zuko_Mapeneng_1	Other (please specify)	Masopha	-30.26	28.424	Unprotected Spring		Single/Multiple eyes
5	motobatsinthunya	motobatsinthunya-92HELX	2020/12/15	Motobatsi -Mepeneng-2	Other (please specify)	Masopha	-30.262	28.4254	Unprotected Spring		Single/Multiple eyes
6	Pabatso Taele	Pabatso Taele-92HPBS	2020/12/15	MapengPabatso1	Moshoeshoe	Mapeng	-30.239	28.6263	Unprotected Spring		Single/Multiple eyes
7	Khiba	Khiba-92HQUT	2020/12/15	Resitsitsoe Mosuang_Ha Khopo	Other (please specify)	Nkau A/A	-30.242	28.5472	Protected spring		Single/Multiple eyes
8	Khiba	Khiba-92HSG9	2020/12/15	Resitsitsoe Mosuang_Tshikaron	Other (please specify)	Nkau A/A	-30.242	28.5514	Protected spring		Single/Multiple eyes
9	Zuko kibi	Zuko kibi-92HRQQ	2020/12/15	Zuko_MasophaKabaka_1	Other (please specify)	Masopha	-30.265	28.4244	Unprotected Spring		Multiple eyes in close
10	Pabatso Taele	Pabatso Taele-92HS8P	2020/12/15	MapengPabatso3	Moshoeshoe	Mapeng	-30.237	28.6271	Unprotected Spring		Single/Multiple eyes
11	Khiba	Khiba-92HTGF	2020/12/15	Resitsitsoe Mosuang_Kokosi_2	Other (please specify)	Nkau A/A	-30.243	28.5527	Protected spring		Single/Multiple eyes
12	Pabatso Taele	Pabatso Taele-92HTYB	2020/12/15	Pabatso_Mapeng_4	Moshoeshoe	Mapeng	-30.239	28.6275	Unprotected Spring		Single/Multiple eyes
13	Khiba	Khiba-92HUVZ	2020/12/15	Resitsitsoe Mosuang_Kokosi_3	Other (please specify)	Nkau A/A	-30.243	28.5554	Unprotected Spring		Single/Multiple eyes
14	motobatsinthunya	motobatsinthunya-92HU39	2020/12/15	Masopha-Maqheqheng-1	Other (please specify)	Masopha	-30.267	28.4226	Unprotected Spring		Seep from Sub Soil
15	motobatsinthunya	motobatsinthunya-92NRMN	2020/12/17	Motobatsi-Mapeneng-2	Other (please specify)	Masopha	-30.26	28.4289	Unprotected Spring		Single/Multiple eyes
16	Nkemeleng	Nkemeleng-92NSQY	2020/12/17	Nkemeleng,Lungiswa _madube	Sibi	Malubaluba	-30.28	28.8108	Unprotected Spring		Seep from Sub Soil
17	Zuko kibi	Zuko kibi-92NY7J	2020/12/17	Zuko_Mapeneng_3	Other (please specify)	Masopha	-30.263	28.4425	Unprotected Spring		Single/Multiple eyes
18	motobatsinthunya	motobatsinthunya-92P29U	2020/12/17	Motobatsi-Mapeneng-4	Other (please specify)	Masopha	-30.265	28.4384	Unprotected Spring		Multiple eyes in close
19	motobatsinthunya	motobatsinthunya-92PMEQ	2020/12/18	Motobatsi-motheong-1	Other (please specify)	Masopha	-30.276	28.4308	Unprotected Spring		Seep from Sub Soil
20	motobatsinthunya	motobatsinthunya-92RGSC	2020/12/18	Motobatsi-Mmopo-1	Other (please specify)	Masopha	-30.264	28.4399	Unprotected Spring		Single/Multiple eyes
21	Zuko kibi	Zuko kibi-92RGNL	2020/12/18	Zuko_Dikamoreng_1	Other (please specify)	Dikamoreng	-30.27	28.4424	Unprotected Spring		Multiple eyes in close
22	Zuko kibi	Zuko kibi-92RRGQ	2020/12/18	Zuko_Dikamoreng_2	Other (please specify)	Dikamoreng	-30.269	28.4437	Unprotected Spring		Single/Multiple eyes
23	motobatsinthunya	motobatsinthunya-92RSQ4	2020/12/18	Motobatsi-Madumeleng-2	Other (please specify)	Dikamoreng	-30.271	28.4443	Unprotected Spring		Seep from Sub Soil
24	Zuko kibi	Zuko kibi-92RUR4	2020/12/18	Zuko_Dikamoreng_3	Other (please specify)	Dikamoreng	-30.27	28.4458	Unprotected Spring		Multiple eyes in close
25	Zuko kibi	Zuko kibi-92RWR2	2020/12/18	Zuko_Dikamoreng_4	Other (please specify)	Dikamoreng	-30.272	28.4458	Unprotected Spring		Seep from Sub Soil
26	Nkemeleng	Nkemeleng-92ZCWW	2020/12/21	Nkemeleng_Lungiswa_zwelicha	Sibi	Zwelicha	-30.241	28.8422	Unprotected Spring		Seep from Sub Soil
27	Khiba	Khiba-94TAXS	2021/01/12	Resitsitsoe Mosuang_George_M	Other (please specify)	Dinaoeng	-30.229	28.5472	Unprotected Spring		Multiple eyes in close
28	Zuko kibi	Zuko kibi-94TAJW	2021/01/12	Zuko_Letswapong_1	Moshoeshoe	Letswapong (N	-30.271	28.4631	Unprotected Spring		Single/Multiple eyes
29	motobatsinthunya	motobatsinthunya-94TC7D	2021/01/12	Motobatsi-Letswapo-2	Moshoeshoe	Letswapo(Mpl	-30.271	28.4632	Unprotected Spring		Seep from Sub Soil
30	Zuko kibi	Zuko kibi-94TFJJ	2021/01/12	Zuko_Dikamoreng_1	Moshoeshoe	Dikamoreng	-30.271	28.4557	Unprotected Spring		Single/Multiple eyes
31	Nkemeleng	Nkemeleng-94TGEH	2021/01/12	Nkemeleng_Lungiswa_Sibi_mar	Sibi	Mangema	-30.248	28.8096	Unprotected Spring		Seep from Sub Soil

Main | Ready | Count: 334 | 130%

Appendix D: Low Streamflow Events - Standardized Streamflow Index (SSI) > 0.8), Matatiele

Station 1: V1H009				
Start year	Start month	End year	End month	Drought duration (Months)
1985	4	1985	8	5
1994	**11**	**1995**	**8**	**10**
2000	10	2000	12	3
2002	10	2003	1	4
2007	1	2007	4	4
2009	**3**	**2010**	**6**	**16**
2011	10	2012	5	8
2014	5	2014	7	3
2014	12	2015	4	5
2018	9	2018	12	4
2019	8	2019	10	3
2020	7	2020	10	4
Station 2: V1H026				
Start year	Start month	End year	End month	Drought duration (Months)
1985	3	1985	8	6
1986	**5**	**1987**	**2**	**10**
1987	4	1987	6	3
1989	**8**	**1990**	**11**	**16**

1991	**11**	**1993**	**7**	**21**
1994	**5**	**1995**	**9**	**17**
2007	1	2007	3	3
2015	10	2016	3	6
2018	10	2019	1	4
2020	3	2020	10	8
Station 3: V1H041				
Start year	Start month	End year	End month	Drought duration (Months)
1985	3	1985	7	5
1992	**1**	**1992**	**12**	**12**
1994	9	1994	12	4
2007	1	2007	7	7
2015	8	2015	12	5
2018	9	2019	2	6
2019	**7**	**2020**	**10**	**16**

Appendix E: High streamflow events- Standardized Streamflow Index (SSI) > 0.8), Matatiele

Station 1: V1H009				
Start year	Start month	End year	End month	Drought duration (Months)
1987	6	1988	6	13
1995	10	1996	7	10
1996	11	1997	8	10
2001	7	2001	10	4
2005	1	2005	3	3
2008	12	2009	2	3
2010	9	2010	11	3
Station 2: V1H026				
Start year	Start month	End year	End month	Drought duration (Months)
1987	7	1987	10	4
1988	1	1988	3	3
1988	12	1989	2	3
1995	12	1996	2	3
1997	3	1997	7	5
1999	10	2000	5	8
2000	7	2000	10	4
2001	3	2001	11	9
2002	5	2002	10	6
2005	12	2006	5	6

2007	9	2008	3	7
2008	9	2009	3	7
2010	10	2011	1	4
2011	3	2011	8	6
2012	7	2012	12	6
2013	2	2013	5	4
Station 3: V1H041				
Start year	Start month	End year	End month	Drought duration (Months)
1987	7	1987	10	4
1988	1	1988	3	3
1988	5	1988	7	3
1995	10	1996	2	5
1996	6	1996	8	3
1997	3	1997	7	5
2000	3	2000	5	3
2001	7	2001	11	5
2002	6	2002	8	3
2005	12	2006	6	7
2008	11	2009	2	4
2010	10	2011	1	4
2011	4	2011	6	3
2012	7	2012	10	4

Appendix F: Ethical Clearance Certificate

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 October 2021

Joyce Loza (T20210194)
EZEMVELO KNN WILDLIFE

Dear J Loza,

Protocol reference number: HSSREC/00003527/2021
Project title: Promoting the adaptive capacity of rural communities to climate change through holistic catchment management: A Case Study of ground-water dependent communities in two catchments
Non-Degree

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 18 October 2021 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 22 October 2022.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

Professor Dipane Hlalele (Chair)

ANNEXURES

Annexure 1: List of individuals who attended various stakeholder engagement sessions and contributed by sharing information with the research team

First Name	Surname	Institution
Agnes Tiyapo	Masenya	DWS
Amanda	Nyingwa	GIZ ZA
Amohelang	Sibi	Inhlabathi
Ayanda	Lepheana	GroundTruth
Ayanda	Cele	WWF SA
Batho	Mosuang	ERS
Bawinile	Mtolo	INR – AmaZizi
Bheki	Gwala	KZN EDTEA
Bongani	Khumalo	Okhombe, EmaZizini
Brigid	Letty	INR
Caiphus	Ngubo	KZN EDTEA
Chief Hlatshwayo	Hlatshwayo	AmaSwazi Traditional Authority
Chief Menzi	Hlongwane	AmaNgwane Traditional Authority
Chief Miya	Miya	AmaZizi Traditional Authority
Chief Sibi	Sibi	Sibi Traditional Authority
Chris	Jackson	LIMA
Dean	Ricketts	EC DEDEAT
Derrek	Ruiters	EKZNW
Fezile	Matandela	CSA
Izelda	Mbatha	WRC
Jack	Marange	uThukela District Municipality
Joseph	Mbokazi	uThukela District Municipality
Khayelihle	Dlamini	OLM
Komisi	Lebenya	Thabachicha A/A/
Kwanele	Mbatha	Newstand, EmaZizini
Lara	Jordan	EWT
Lentsoe	Tsehlohane	Eastern Cape Water Caucus
Leonard	Chitongo	UKZN
Lungiswa	Nongalo	ERS
Mahabe	Mojela	ERS
Mark	Graham	GroundTruth

Mfanafuthi	Khumalo	Okhombe, EmaZizini
Mhlonipheni	Madlala	EKZNW UNESCO MDP WHS COMPACT - EmaZizini
Michael	Maluleke	KZN DWS
Michael	Malinga	Mahlathini Development Foundation (MDF)
Motebang	Lepheana	Mafube
Musa	Dlamini	OLM
Mzokhona	Hlongwane	Sandlwane, AmaNgwane
Mzukisi	Khuse	Rhodes University
Nceba	Makhoba	Makhoba Traditional Council (TC)
Nelisiwe	Hlongwane	Sandlwane, AmaNgwane
Nicky	McLeod	ERS
Nkosinjani	Mkhize	KZN DWS
Nkosithandile	Ndlovu	Okhombe, EmaZizini
Nomalungelo	Ndlovu	SANBI
Nomsa	Sibeko	VukaMngoma and Dabulamanzi Sanctuary of Healing
Nomzamo	Phakamisa	ERS
Nonto	Hlatshwayo	INR – AmaZizi
Nosisa	Ndaba	EC DEDEAT
Nosiseko	Mtati	Rhodes University
Notiswa	Libala	Rhodes University
Omega	Kubone	KwaZulu Natal Department of Agriculture and Rural Development (KZN DARD)
Papiso	Hoffman	UKZN
Phumlani	Khumalo	UTAKU
Relebohile	Lebata	Organisation not identified
Remember	Hlongwane	Enkosini, EmaZizini
Robert	Mnika	ANDM
Rofhiwa	Madilongo	WRC
Rosanne	Stanway	CSA
Samir	Randera-Rees	WWF SA
Samson	Phakathi	Endangered Wildlife Trust (EWT)
Sandile	Mokoena	Yametsi Trading Enterprise
Sandiselo	Majola	uThukela District Municipality
Sanele	Zikalala	uThukela District Municipality

Sazumzi	Nibe	DALLRD
Shadrack	Buthelezi	DFFE
Silulamile	Nkosana	Nkosana TC
Simangele	Miya	EKZNW UNESCO MDP WHS COMPACT - EmaZizini
Sissie	Matela	ERS
Skhwenyana	Makape	Tabanadihlolo
Smuts	Smuts	George Moshoeshoe
Tembeka	Dambuza	DUCT
Thabang	Kuali	Contralesa
Thabiso	Erasmus	LIMA
Thabo	Sithole	ERS
Tiisetso	Ramogayane	SANBI
Tsamaelo	Malebu	SANBI
Tsamaelo	Malebu	SANBI
UNM	Baleni	Mzongwana A/A
Vusi	Khoza	Okhombe, EmaZizini
Xolani	Sibiya	EKNZW – MDTP
Zamuxolo	Mboqoka	Makhoba A/A
Zanele	Shezi	INR